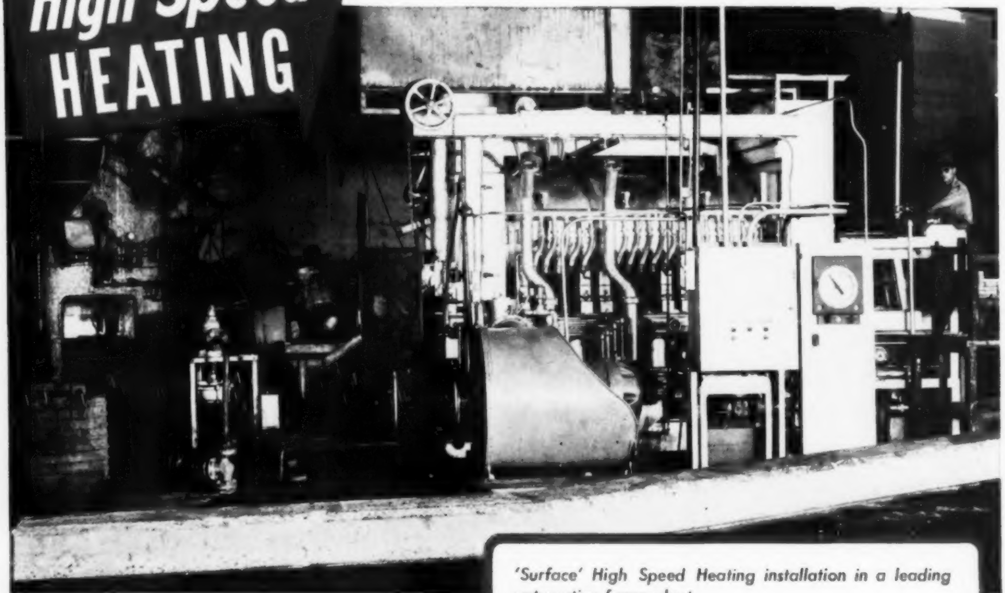
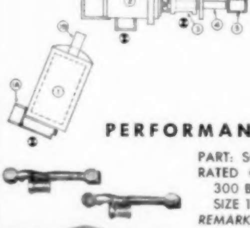
METAL

PROGRESS

'Surface' High Speed HEATING for Production Forging



'Surface' High Speed Heating installation in a leading automotive forge plant.



PERFORMANCE DATA

PART: Steering knuckle support.
RATED CAPACITY OF FURNACE:
300 Billets (17 lbs. ea.)
SIZE 19" x 2¼" x 1¼"
REMARKS—
Die life increased 16%
Scrap loss less than 2%
Maintenance less than $.30/ton
FURNACE: Automatic pusher type equipped with dampers for atmosphere control.

'Surface' High Speed Heating Furnaces have been making performance records wherever they have been installed in leading production forging plants. Increased production . . . better quality of product and work . . . improved working conditions, all without added floor space, combine to make these furnaces the choice over other heating methods.

Now, you can create New Profits in Production Forging by converting to 'Surface' High Speed Heating. More descriptive data on the high speed combustion system, the furnace unit, application and comparative costs are available in 'Surface' Bulletin SC-144. Write for your copy—today!

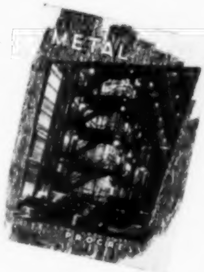
SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

FOREIGN AFFILIATES: Stein & Roubaix, Paris British Furnaces, Ltd., Chesterfield

'Surface' INDUSTRIAL FURNACES

FOR: Gas Carburizing and Carbon Restoration (Skin Recovery), Homogeneous Carburization, Clean and Bright Atmosphere Hardening, Bright Gas-Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleableizing and Atmosphere Forging. Gas Atmosphere Generators.

IN THIS ISSUE



RETURN YOUR SCRAP

Brass mills must have it to make mill products

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As I was saying—

A.S.M. HEADQUARTERS is a beehive of multitudinous activities and there is no queen bee or drone in the hive (that I know of). So here's what's going on:

President John (Chipman of M.I.T. and A.S.M.) making hay (chapter visits) while the sun shines — has a substitute taking his classes this semester. Being splendidly received — a royal welcome. Traveling now on the last leg of his way-down-south trip.

Ernest (Thum, Editor of M. P.) digging up more engineering information for transmission to you in Feb. issue. Pinch-hitting at National Officers' Nights. Interviewing prospective additional editors (two) for M. P. — will continue to produce best gol-darn magazine in the metals field.

Ray (Bayless, Asst. Sec.) making final arrangements for Midwinter Meeting with 20 top papers. Flying to Easton, Chicago, Toronto, to secure printer for 's new high-brow magazine (baby not yet named) — to Denver and Pueblo for Chapter talks. Giving O.K.'s to forms for printing *Transactions*, Vol. 44. Sending invitations for papers for the Phila. (Oct. '52) and Los Angeles (March '53) meetings.

Marjorie (Hyslop, Editor of M. R.) preparing metal literature reviews for printing in book form. Preparing annual employment section for junior members. Urging Chapter correspondents to send reports. Arranging final lists of W.M.C. Overseas and American conferees for engrossed certificates.

Taylor (Lyman, Publisher of M. P., Editor of Handbook) thinking up more and better ways to keep increasing the increase in advertising in M. P. Training additional sales personnel. Managing advisory committees to the Department of Defense, Navy Division. Still waiting for someone to write a letter pointing out an error, either of fact or type, in the last edition of the Metals Handbook.

Chet (Wells, Asst. Dir., National Metal Exposition) completing a speedy six-weeks' trip through Europe visiting the 60 foreign firms that participated in Detroit Show and looking for 60 more for the Philadelphia Show.

Hilda (Eberhardt, Book Orders) completing billing for approximately 6000 copies of books shipped to overseas members of the W.M.C. Filing and cataloguing 10,000 members' orders for *Transactions* and the *Proceedings of the World Metallurgical Congress.*

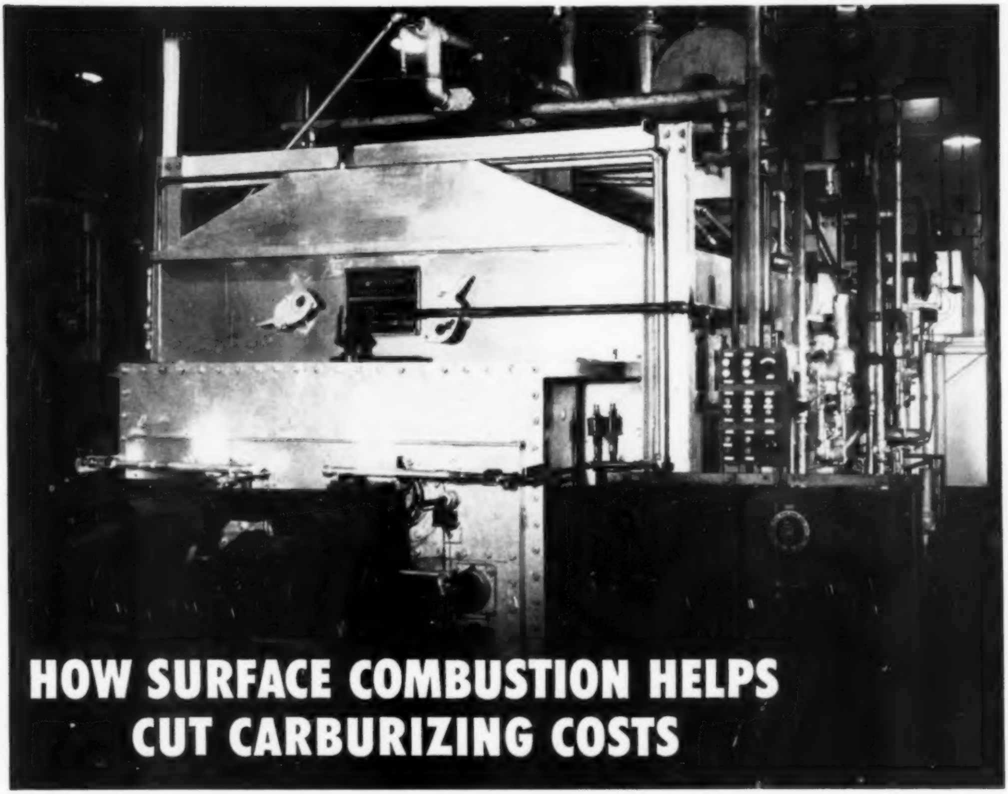
Walter (Morrison, Public Relations) working with committees on educational problems — newest addition, Advisory Committee on Vocational Education. Now living with National Science Teachers Assoc. on a nation-wide project to interest junior (7-9) and senior (10-12) high school students in making engineering their life's profession.

What's that you said? I don't mind tellin' you, pardner, them's fightin' words — but since you are a paying member, you have a right to ask, and I'll tell you. *I'm* ridin' herd on the pack and practicing with my 15-ft. blacksnake to emulate my ol' friend Simon Legree. From whar I sit on the driver's seat of this mule-train, I want to tell you, pardner, the road ahead looks mighty, mighty good. I'll be meetin' you 'round the bend — then we'll bend the elbows!

Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS



*with rotary retorts cast in Thermalloy**

A main part of the inside story of this Surface Combustion continuous carburizing furnace is the rotary retort we cast for it. Developed and built by Surface Combustion Corporation, these furnaces with Thermalloy retorts are operating successfully in a number of roller bearing and automotive parts plants.

To make sure small parts pass through the spiral cycle and are discharged at exactly the right time, the passage must be free from obstructions. No part can be allowed to "hang up" and carburize too deeply, since individual inspection of parts is impractical. Thanks to careful foundry practice and a unique method of cleaning castings internally, these 16′ retorts operate precisely as designed.

For retorts, furnace parts, trays, racks, pots, muffles—Thermalloy gives you more operating hours per dollar. Whatever your heat-and-abrasion-resistance problem, our engineers will help you select the right grade of Thermalloy, engineer the casting and foundry practices necessary to produce it for lowest cost service life. On your next problem, why not call in an Electro-Alloys engineer? Write Electro-Alloys Division, 2092 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

AMERICAN **Brake Shoe** COMPANY

ELECTRO-ALLOYS DIVISION

ELYRIA, OHIO

1 350 lb. furnace installed 1925
1 350 lb. furnace installed 1925
1 350 lb. furnace installed 1937
1 700 lb. furnace installed 1941
1 700 lb. furnace installed 1942
average age 17 years

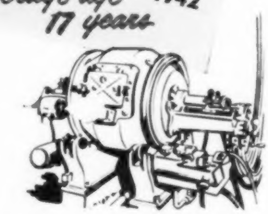
Detroit ROCKING Electric Furnaces build long service record—melting bronze for the Jeffrey Company foundry

At The Jeffrey Manufacturing Company, Columbus, five Detroit Electric Furnaces have made excellent records melting bronze for worm wheels, bearings, bushings, electrical contacts, and pressure-type castings. In hundreds of other foundries, Detroit Furnaces are doing equally outstanding jobs melting bronze, iron, and steel alloys.

Detroit Rocking Electric Furnaces turn out fast melts of uniform high quality metal. Close control of analysis produces metal of desired analysis time after time, with optimum use of power. The melts are homogeneous, thoroughly mixed by the rocking action of the furnace. Electrodes are free of the molten metal at all times, reducing carbon pick-up to an absolute minimum.

Long life of Detroit Electric Furnaces is documented by such installations as that shown. Economies are proven, too—accomplished by full use of power, less heat loss, reduced metal shrinkage, more heats per day, less metal waste per melt, and reduced out-of-production time because of longer refractory wear and easy shell replacement.

Detroit Rocking Electric Furnaces are tailored to your operating needs. Capacities from 10 to 4000 pounds, for ferrous and non-ferrous melting.

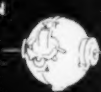


Better melts, faster melts—rocking action does it! Get the facts on what Detroit Rocking Electric Furnaces can do for you! Send us your data now!

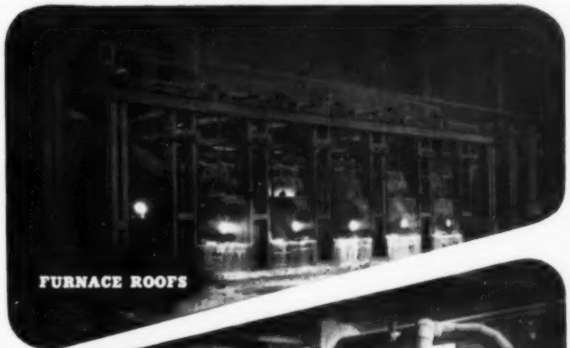
DETROIT ELECTRIC FURNACE DIVISION

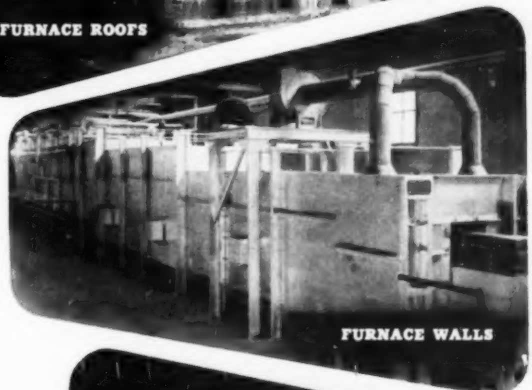
KUHLMAN ELECTRIC COMPANY, BAY CITY, MICHIGAN

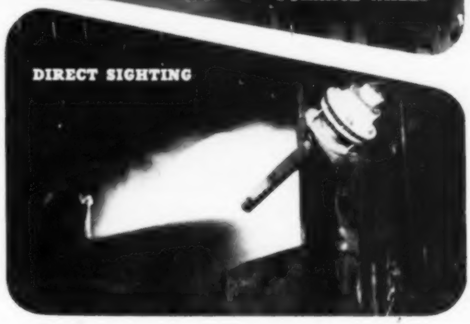
Foreign Representatives: In BRAZIL—Equipamentos Industrias, "Eisa" Ltd., Sao Paulo, CHILE, ARGENTINA, PERU and VENEZUELA: M. Castellvi Inc., 150 Broadway, New York 7, N. Y., MEXICO: Casco, S. de R. L. Atenas 32, Despacho 14, Mexico City, D. F. EUROPE, ENGLAND: Birlec, Ltd., Birmingham



This RAYOTUBE suits all locations COOL OR HOT







FEATURES:
Quick installation
" sighting
" response to temperature

Here is the radiation-sensing unit for 9 out of every ten radiation-pyrometer uses. It adds the storekeeping advantages of smaller instrument inventory to the operating advantages* of all Rayotubes. Many hundreds of this type are now in use. Among its features:

1. Easy to install because it needs no water-jacket unless the head housing itself (shown above) reaches interior temperature of 350 F. Even then, no harm is done below 450; accuracy decreases above 350, but returns fully as temperature drops. In practical operation, even 350 is reached on very, very few installations.

When replacing a present jacketed Rayotube with this type, it is not necessary to tear out the jacket and piping. Simply insert Rayotube in jacket and turn off water if no longer needed.

2. New, quick-sighting optical system shows exact area from which temperature is being recorded. This is especially helpful when instrument is being positioned to point down an open-end tube and measure directly the surface temperature of parts being heated.

3. Can be used with Speedomax electronic instruments as well as with Micromax equipment—which blanket every temperature-recording and/or controlling job in industry.

This Rayotube is No. 8890. Any L&N office, or headquarters at 4927 Stenton Ave., Phila. 44, Pa., will send details on request.

LEEDS & NORTHRUP
MEASURING INSTRUMENTS · AUTOMATIC CONTROLS · TELEMETERS
HEAT-TREATING FURNACES

*Any L&N man can give details

Jrl. Ad NS3(3)

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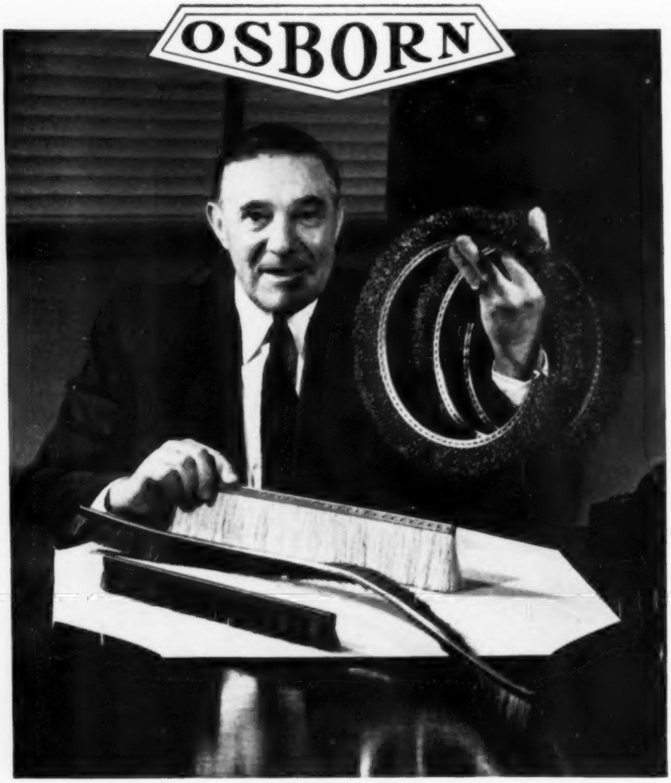
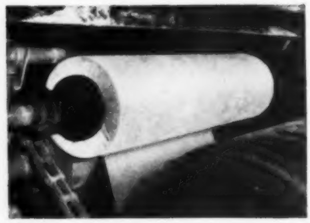




SCRUBS STEEL. Master Strip wound helically around a steel core becomes an Osborn Heli-Master® Brush. Here it scrubs strip steel preparatory to electrolytic tinning. In this mill, six of these Heli-Master Brushes clean the strip at 1500 feet per minute, working around the clock.

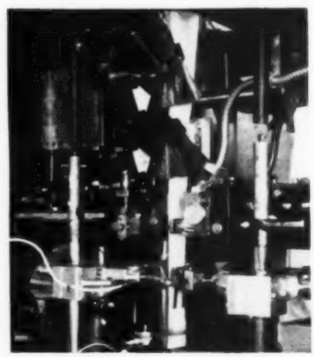
PREPARES GLASS. Here Heli-Master brushes clean glass and apply a uniform film of binder for silvering compound. Replace hand operation. Steps up mirror production and cuts rejects.

Heard about these ways to find manpower?

And cut costs! Every manufacturer should know about this brush . . . the Osborn Master® Strip. In its more than a thousand forms, shapes and sizes, this power brush . . . at the push of a button . . . is doing jobs formerly requiring many skilled hands. It is boosting output, improving product quality and slashing costs.

Master Strip can be used in special mountings—straight, curved or coiled in a helix. Its fill material can be wire, hair, fibre, textiles or synthetics in trim lengths from 1 to 10 inches. It comes in any length up to 120 inches. Name your problem—cleaning, scrubbing, finishing or many others. It can be matched to *your* job!

The nearby **O**sborn **B**rushing **A**nalyst will gladly study *your* manufacturing operations and explain how you can benefit with this versatile tool! Call today or write *The Osborn Manufacturing Company, Dept. 634, 5401 Hamilton Avenue,* Cleveland 14, Ohio.



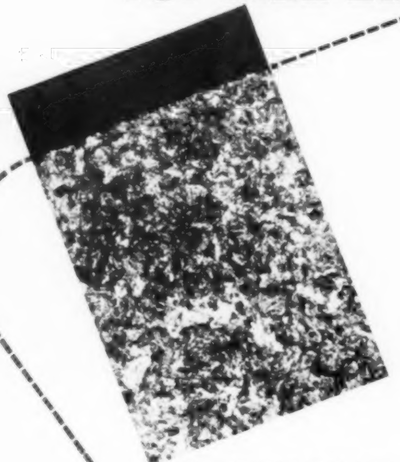
KILLS STATIC. These brass wire Strip Brushes are used in a tea-bagging machine to remove static from the bag paper. Speeds filling and sealing of bags.

Osborn Brushes

WHAT'S YOUR PROBLEM?
The **O**sborn **B**rushing **A**nalyst nearby will gladly help. Call him today!

OSBORN POWER, MAINTENANCE AND PAINT BRUSHES AND FOUNDRY MOLDING MACHINES

SCALE FREE—DECARB FREE Hardening for ALL Engineering Steels



Photomicrograph showing absence of scale or decarburization in a section of S.A.E. 1085 steel (X100) neutral salt bath hardened at 1500 F. and quenched in oil. (Etched in 2% Nital.)

By its very nature the Ajax Electric Salt Bath Furnace guards against pitting, scaling, carburizing or decarburizing in the hardening of carbon, alloy, stainless and high carbon-high chromium steels in the temperature range from 1450° F. to 1950° F. The liquid neutral salt bath not only prevents these surface effects by sealing the work from air during heating, but leaves a protective film of salt on it right up to the moment of quenching. All need for "protective atmospheres," gas generating equipment and specially trained operators is eliminated.

Heating cycles are from 4 to 6 times faster than in atmosphere or radiant type furnaces, thus enabling small, relatively inexpensive salt bath equipment to handle an amazing volume of work. Heat is transferred by conduction rather than by convection or radiation, all surfaces of the work being in direct contact with the molten salt. Heating is extremely rapid and uniform. Distortion is reduced to a negligible minimum.

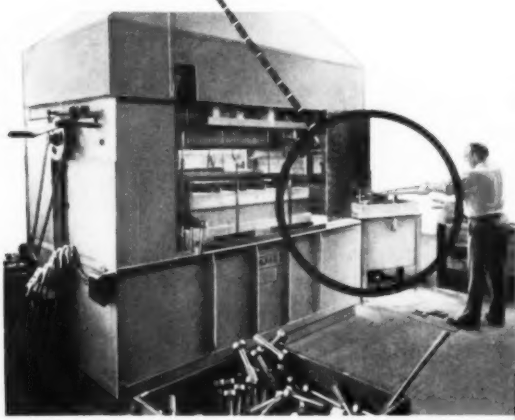
The unique internal heating principle of the Ajax furnace produces an automatic electrodynamic stirring action which contributes to rapid heating and assures a temperature variation of *less than 5° F.* throughout the bath.

Ajax furnaces assure low operating and maintenance costs and no skilled labor is required. Ceramic pots last 5 years or longer (many are still in use after 8 years continuous service).

AJAX ELECTRIC COMPANY, Inc.

WORLD'S LARGEST MANUFACTURER OF ELECTRIC HEAT TREATING FURNACES EXCLUSIVELY

910 Frankford Avenue Philadelphia 23, Pa.

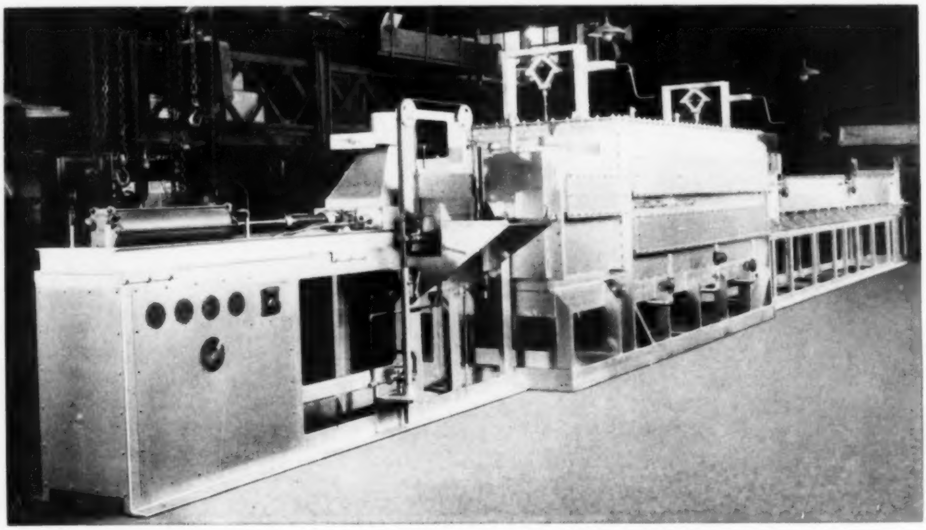


Automotive spline shafts being heated in a neutral salt bath equipped with a screw-conveyor mechanism. Temperature of the work is held within 5°F. even in this relatively large bath —6 ft. long, 2 ft. wide and 2 ft. deep.

SEE FOR YOURSELF!

AJAX ELECTRIC SALT BATH FURNACES

SELF-HEATING • SELF-CIRCULATING



HARPER Production Heat Treating Furnaces

TYPES

Mesh Belt
Pusher Type
Bell
Elevator
Pit
Car Bottom
Box
Wire & Strip
Forging

PROCESSES

Continuous Brazing
Sintering
Bright Annealing Stainless Wire
High Speed Steel Heat Treating
Billet & Bar Heating
Annealing
Melting in Crucibles
Forging
General Heat Treating

GIVE: ***Dependable, Efficient, Low-Cost Service***

For the finest in dependable, efficient, low-cost service, select a Harper Electric Furnace for your next heat treating operation. They are available in several standard sizes to meet your general heat treating needs. For special heat treating processes, take advantage of the knowledge and experience that Harper Engineers can give you and let them work with you on special process furnaces to meet your exact requirements.

Write for descriptive literature.

Harper

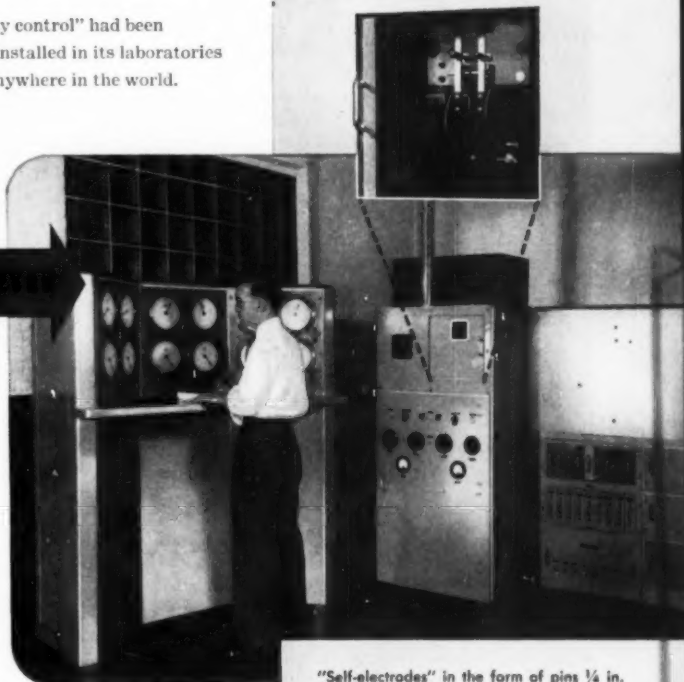
HARPER ELECTRIC FURNACE CORPORATION

Dept. 7, 39 River Street, Buffalo 2, New York

LEADERSHIP can't stand still

this time it advances on spectral waves

Way back in 1914, before the term "quality control" had been invented, The American Brass Company installed in its laboratories the *first* spectrograph used by industry anywhere in the world. Today, this Company, first in its field, has introduced the latest word in rapid analytical procedures, the . . .



DIRECT READING SPECTROMETER

What it does

In five minutes by spectrochemical methods this instrument completes an analysis that would take several hours by spectrographic procedures and several days by the traditional methods of chemical analysis. Now an electric furnace charge of molten metal can be analyzed *before* it is poured.

"Self-electrodes" in the form of pins ¼ in. diameter by 2 in. long, cast from a sample of the melt to be analyzed, are accurately spaced in the electrode holders of the Baird Associates—DOW Direct Reading Spectrometer (top illustration). A button is pressed—and a 25,000-volt spark bridges the gap. Then...

Light from the spark falls on a grating and is reflected, in a separate spectrum line for each element, onto photomultiplier tubes. Seconds later, accurate, direct dial readings indicate the amount of alloying elements present and the amount of impurities, such as iron, nickel, manganese, aluminum, silicon, lead, arsenic, phosphorus and antimony.

What it means

This continuing leadership in the application of scientific developments to production has many practical advantages. For instance: In conserving copper and zinc by making maximum use of scrap in such an important alloy as cartridge brass. The rapid, complete analysis for metal content and impurities permits a high degree of control not otherwise possible. Thus, through the development of spectrochemical analysis you are assured of new high standards of uniformity in Anaconda Metals—unsurpassed by *any* in the industry. The American Brass Company, General Offices, Waterbury 20, Connecticut. 5207

With the analysis of the melt known to be right, a "go-ahead" is flashed to the casting shop and the metal is poured.

ANACONDA

sets the pace in quality control of

COPPER and COPPER ALLOYS

WHEREVER TOOL STEELS ARE APPLIED . . .

Watch this Personalized Program

produce production results you always wanted !

This program is designed by specialists *expressly for* the plant that makes or uses tools and dies.

It brings you practical ideas to improve and speed every step from toolmaking through finished production. It starts with information to help toolmakers and heat treaters get better results . . . and includes data that enables you to squeeze more output from production facilities. And this personalized program is yours at no extra cost, when you ask your Carpenter representative to bring it to you.

Here's what it embraces: Information ranging from tool steel selection and heat treating to trouble prevention, yours in regular Service Bulletins. Methods for lengthening die life and conserving tool steel, found in Carpenter's Matched Tool and Die Steel Manual. Data that saves tooling time and money, available in Carpenter's Tool Steel slide chart and selector wall chart. All this ...plus mill metallurgical cooperation that forms the foundation of the entire program.

This is the imagination and practical help that ride along with every bar of Carpenter Tool Steel you use. For production results you always wanted, put this program to work. THE CARPENTER STEEL COMPANY, 133 W. Bern St., Reading, Pa.

Call your Carpenter Representative for this Personalized Program on

Carpenter

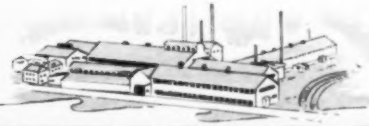
MATCHED TOOL & DIE STEELS

DON'T WAIT... COOPERATE!

The U.S. Needs Your Steel Scrap, Now

Export Department: Carpenter Steel Co., Reading, Pa.—"CARSTEELCO"

Mill-Branch Warehouses and Distributors in Principal Cities Throughout the U. S. A. and Canada



PITTSBURGH *Mechanical* STEEL TUBING

Available **in the following sizes:**

Diameters.....½" to 2½"
Gauges.......095 to .375

S.A.E...............1010 to 1015
U.S.A. Specification.....57-180 D
W.D.-1010-1015 TYPE IV

•

For over a quarter of a century, Pittsburgh Tube Company has continuously supplied impressive quantities of Cold Drawn Butt Welded Mechanical Steel Tubing to relatively few very large manufacturers. Due to increased and expanded plant facilities many sizes are now available for new customers and new uses.

Tubing may be purchased in...

• MILL LENGTHS • CUT LENGTHS
• FABRICATED TO SPECIFICATION

THE PITTSBURGH TUBE CO. HAS FURNISHED TUBING:
• FORGED • SWAGED • THREADED

For further information write for Handbook No. 106

PITTSBURGH TUBE Co. PITTSBURGH 22, PA.
Mechanical Tubing

Phone: COurt 1-0902

Incorporated 1924

PITTSBURGH TUBE COMPANY PCT

COLD DRAWN BUTT WELDED MECHANICAL STEEL TUBING

BECKMAN *Model* IR-2

Infrared Spectrophotometer

The Model IR-2 Infrared Spectrophotometer is unsurpassed for accuracy, convenience, and overall usefulness in research investigations, analytical laboratory determinations and for the continuous automatic control of plant streams.

Many design features contribute to the convenience and speed of operation of the IR-2: Elimination of zero drift and non-linearity through the use of chopped radiation and an a-c amplifier; minimized stray energy by advanced optical design and employment of a filter-beam chopper; construction in separate compartments, making the IR-2 the most adaptable instrument available; Incorporation of a turret-stop mechanism for quick, accurate setting to predetermined wave lengths; collimation of the radiation beam so that the focus is unaffected by substituting special cells of various lengths; direct calibration of the monochromator in wavelength units to eliminate conversion charts; dual gas cells independently filled and positioned without removal from their compartment.

The Beckman Model IR-2 excells in performance: precise reproducibility of transmission measurements; high resolution of better than 3 cm^{-1} at 10 microns; reduction of stray light to less than 1 per cent at 14 microns and to less than 2 per cent at 15 microns; excellent reproducibility of slit and wavelength settings; constant energy output of the source; linear detecting and amplyfying system not subject to uncontrolled fluctuation in sensitivity.

The instrument's fundamental design is similar to that which has proven so successful in the well-known Beckman Model DU Quartz Spectrophotometer. The model IR-2 is constructed of separate units which are easily assembled and disassembled. A rugged, sealed monochromator mounted in a steel housing is the principal unit. To this are attached three other units in the standard instrument; the light-source compartment, the gas-cell and energy receiver compartment, and the liquid-cell compartment. Because other units such as special radiation sources or receivers, or different cells and cell compartments can be attached as desired, the instrument is readily adaptable to specialized measurements and to the changing requirements of research and plant control.

MODEL IR-2S SPECTROPHOTOMETER. Comprised of three units; the instrument assembly with sodium chloride optics, the electronic amplifier, and the power supply for use on 115-volts, 60-cycles. The instrument is assembled with monochromator and three integrally attached units: the energy receiver compartment with thermocouple, the liquid cell compartment, and the light source compartment with phototube regulator, beam chopper and auxiliary metal fixed gas cell, approx. 27-cm. Other cells listed separately. Direct reading wavelength scale 1.0 to 15.0 microns. Shipping weight 400 lbs. **$4650.00**

Contact Harshaw for all Beckman Instruments

See this instrument demonstrated in Booths 18-19, March 5-6-7, 1952 at the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy. Wm. Penn Hotel, Pittsburgh, Pa.

HARSHAW SCIENTIFIC
DIVISION OF THE HARSHAW CHEMICAL CO.
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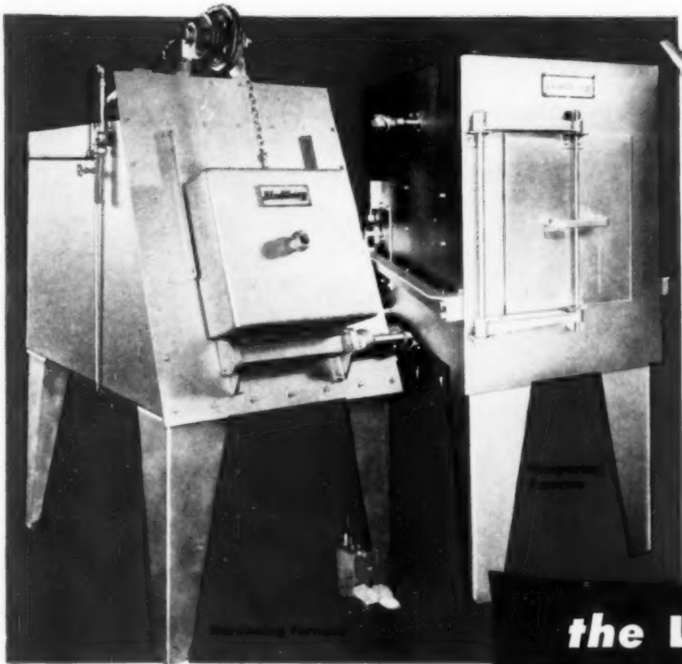


BASIC FOR EVERY TOOLROOM

the LINDBERG TOOLROOM TEAM

When production depends on tools and dies, tools and dies depend on the LINDBERG TOOLROOM TEAM—a basic requirement in every toolroom—a must where you want the ultimate in tools and dies which will keep your production rate up and your machinery running with a minimum of tool and die failure. The LINDBERG TOOLROOM TEAM gives you the precision heat treating which your precision tools and dies need for lasting performance.

LINDBERG HARDENING FURNACE—eliminates finishing due to scale and decarb with simple accurate atmosphere control.

LINDBERG TEMPERING FURNACE—allows you to obtain the exact "Rockwell Hardness" required for each specific tool or die.

For tools and dies requiring high speed tool steel—investigate the Lindberg "L" Type combination preheat—high heat Furnace.

LINDBERG FURNACES

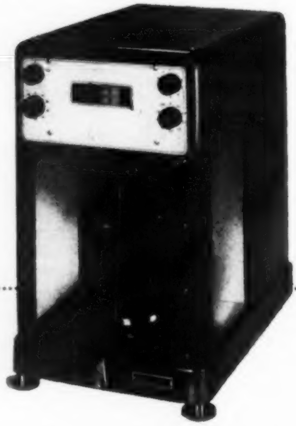
Specify LINDBERG

LINDBERG ENGINEERING COMPANY W. Hubbard Street, Chicago 12, Illinois

FOR AMERICA'S LABORATORIES...

A New, Completely Direct-Reading Analytical Balance . . .

THE *Gram-atic* BALANCE



. . . weighs in one-third the time required by the usual balance.

Its control knobs are manipulated to select built-in weights. Corresponding figures appear on the direct reading scale.

Weights under 100 milligrams are indicated automatically.

The Gram-atic Balance weighs samples up to 200 grams and has constant sensitivity throughout this entire range.

For 115 and 230 volt 50-60 cycle A. C. . . . . . . $895.00 each.

Fast (20 second weighing)
Eliminates all weight handling
Beam under constant load
One-scale reading
Constant sensitivity
Weighs below 100 milligrams automatically

Entire weight of sample is read on direct-reading indicator.

Write for Folder No. 4A

. . .write to any of the five conveniently located plants

Headquarters for Laboratory Supplies

FISHER SCIENTIFIC COMPANY

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See us at Booth 1401, ASTE Show, Chicago, March 17-21, 1952.

TOOL STEEL IS OUR FIRST LOVE!

Tool steel made our reputation. Naturally, tool steel is *our* first love. That's why we are the country's top producer.

Since new requirements for tool steel arise daily in industry, Crucible research and development goes on unabated. That's why users of tool steel have always been able to get not only the finest tool steel—but alert metallurgical advice as well. Draw on Crucible's outstanding background of tool steel experience. When you think of tool steel—call on us. Full stocks are maintained in conveniently-located warehouses.

SEND TODAY for the unique Crucible Tool Steel Selector —a twist of the dial gives the tool steel for your application.

Rex® High Speed Steels
Peerless Hot Work Steels
Halcomb 218
Chro-Mow®
Sanderson Carbon Tool Steels
Ketos®
Airkool Die Steel
Airdi® 150
Nu-Die V Die Casting Steel
CSM 2 Mold Steel
LaBelle® Silicon #2
Atha Pneu

SPECIFY YOUR TOOL STEELS BY THESE BRAND NAMES

Crucible Steel Company of America
Dept. MP, Chrysler Building, New York 17, N. Y.

Name____________________

Company____________ Title________

Address________ City________ State______

9" diameter, 3-colors

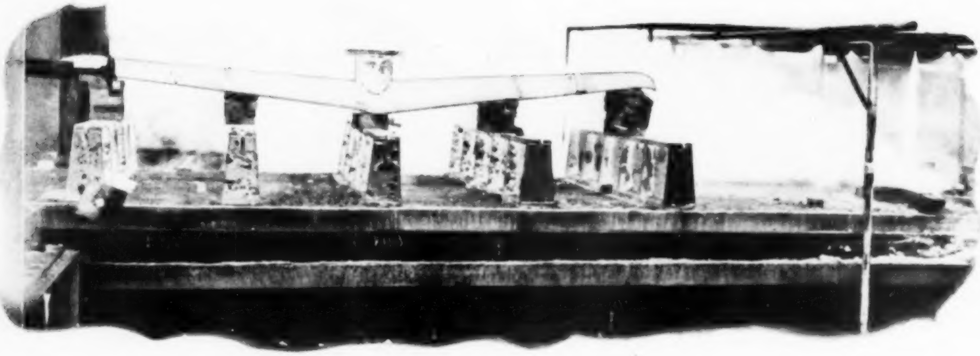
CRUCIBLE first name in special purpose steels

52 *years of Fine steelmaking*

TOOL STEELS

CRUCIBLE STEEL COMPANY OF AMERICA · TOOL STEEL SALES · SYRACUSE, N. Y.

This LUMNITE* car top is
WATER-QUENCHED at 2200° F.!



MISSOURI may be the "Show Me" state. But even after they're shown, some Missourians are still amazed by the way this Lumnite car top absorbs thermal shock at Nooter Corp., St Louis.

From a fiery 2000° F. to 2300° F. annealing furnace, Nooter's big car is rolled under a quenching bath of cold water. A terrific thermal shock! Yet the car top is in excellent condition after seven months service. It may last for years. Some Lumnite car tops have stayed in service several years!

Working with Lumnite fieldmen, Nooter plant officials developed their car top. It has 82 sections, approximately 24" wide, 36" long, 9" thick. It's made from a mixture of Lumnite, crushed fire-brick and Topaz admix. Beneath it is a 5" thick section of insulating concrete. Nooter officials are so pleased with the car tops' performance they are planning to use Lumnite refractory concrete in the walls, sprung-arch roof, foundation, and base slab of a new annealing furnace.

Lumnite calcium-aluminate cement has a proved time and cost-saving record. It gives consistently good performance under severe conditions.

IF YOU'RE IN A HURRY to place practically any refractory . . . use Castable Refractories made with Lumnite. They reach full service strength in 24 hours or less! Castables are easy to use. No skilled labor necessary. They come to you dry, a balanced mixture of aggregates and Lumnite calcium-aluminate cement. All you do is add water and pour into place. Your job will be finished and into production—fast! Buy them from your refractory dealer.

For more information write: Lumnite Division, Universal Atlas Cement Company, (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

NEED REFRACTORIES FAST? By pouring Refractory Concrete, as in this slow-cooling pit, you can save many days over other types of refractory construction.

"LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

MP-L-44R

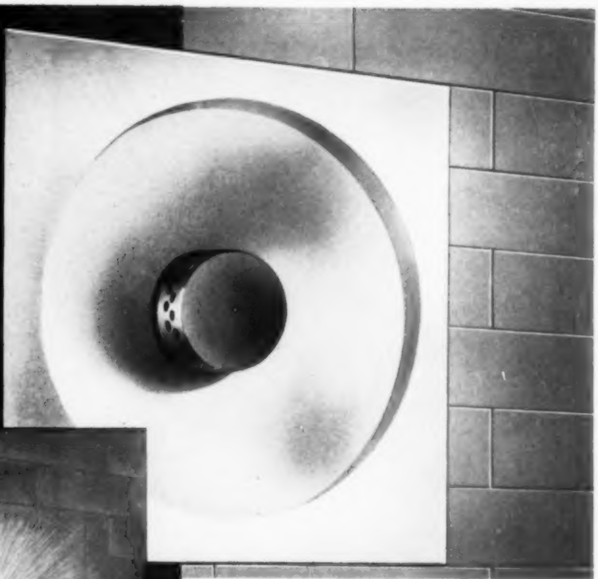
ATLAS® **LUMNITE for INDUSTRIAL CONCRETES**

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

A UNIVERSAL ATLAS PRODUCT

"THE THEATRE GUILD ON THE AIR"—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings—NBC Network*

For precision heating with intense transfer of heat...



the **Bloom**

HTR

HIGH THERMAL RELEASE

BURNER

BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

Recommended for use where quick heating and intense concentration of heat are desired, the Bloom High Thermal Release Burner will release up to 750,000 Btu per hour per cubic foot of combustion volume.

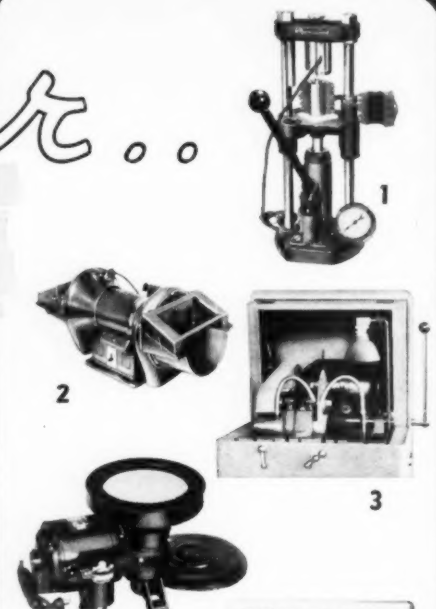
In this nozzle-mix burner, fuel (oil or gas) and combustion air are premixed within the alloy nozzle, forming a uniform, combustible mixture when discharged into the furnace. A turndown ratio of greater than 10 to 1 enables low input for holding purposes.

With this burner, experience has shown that thin sheets can be heated without scale, and forgings can be heated with little or no scale, in a fraction of the time ordinarily required.

Write for bulletin giving full details and description of the Bloom HTR Burner.

Buehler . . .

. . . OFFERS A COMPLETE LINE OF EQUIPMENT FOR THE Metallurgical Laboratory



Buehler specimen preparation equipment is designed especially for the metallurgist, and is built with a high degree of precision and accuracy for the fast production of the finest quality of metallurgical specimens.

1. No. 1315 Press for the rapid moulding of specimen mounts, either bakelite or transparent plastic. Heating element can be raised and cooling blocks swung into position without releasing pressure on the mold.

2. No. 1211 Wet power grinder with 3/4" hp. ball bearing motor totally enclosed. Has two 12" wheels mounted on metal plates for coarse and medium grinding.

3. No. 1000 Cut-off machine is a heavy duty cutter for stock up to 3-1/2". Powered with a 3 hp. totally enclosed motor with cut-off wheel, 12" x 3/32" x 1-1/4".

4. 1505-2AB Low Speed Polisher complete with 8" balanced bronze polishing disc. Mounted to 1/4 hp. ball bearing, two speed motor, with right angle gear reduction for 161 and 246 R.P.M. spindle speeds.

5. No. 1700 New Buehler-Waisman Electro Polisher produces scratch-free specimens in a fraction of the time usually required for polishing. Speed with dependable results is obtained with both ferrous and non-ferrous samples. Simple to operate—does not require an expert technician to produce good specimens.

6. No. 1410 Hand Grinder conveniently arranged for two stage grinding with medium and fine emery paper on twin grinding surfaces. A reserve supply of 150 ft. of abrasive paper is contained in rolls and can be quickly drawn into position for use.

7. No. 1400 Emery paper disc grinder. Four grades of abrasive paper are provided for grinding on the four sides of discs, 8" in diameter. Motor 1/3 hp. with two speeds, 575 and 1150 R.P.M.

8. No. 1015 Cut-off machine for table mounting with separate unit recirculating cooling system No. 1016. Motor 1 hp. with capacity for cutting 1" stock.

THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

Buehler Ltd.
A PARTNERSHIP

METALLURGICAL APPARATUS
165 WEST WACKER DRIVE, CHICAGO 1, ILL.

Facts you should know about U·S·S CARILLOY STEELS

used here in press brake dies...

Pre-hardened Carilloy FC Steel easier to machine than softer steel formerly used

HERE'S THE STORY AS TOLD BY A LEADING PRESS MANUFACTURER:

"We checked 4 bars of CARILLOY FC steel (300 BHN) against 4 bars of ordinary type die steel (250 BHN). Identical press brake dies were made from these steels in our die planer department. Roughing speed was 32′ per minute. Finishing speed was 16′ per minute. Standard high-speed steel tool bits were used.

"The FC steel cut clean. There was no tool damage or wear. The regular steel did *not* cut clean. The chips kept gumming up. Tool wear was substantial. Although the FC steel used is a good 50 points higher in BHN than the regular steel, it works much better.

"The smoother finish of the FC steel is also very important in any press brake die, because the metal being formed is literally dragged over the working points. Since the FC steel dies are smoother, less pressure is needed to make the bend; and the finished part has no scratch marks.

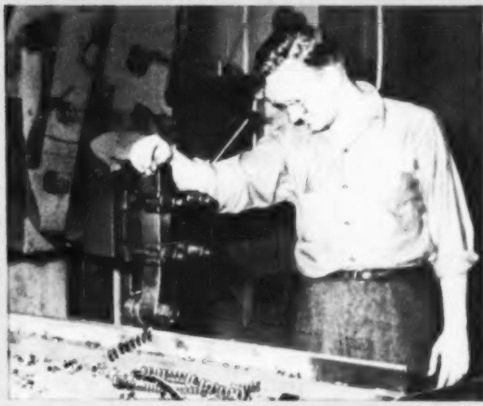
"Even when forming high tensile steels, the 300 BHN hardness of FC steel often makes it unnecessary to re-treat the finished dies."

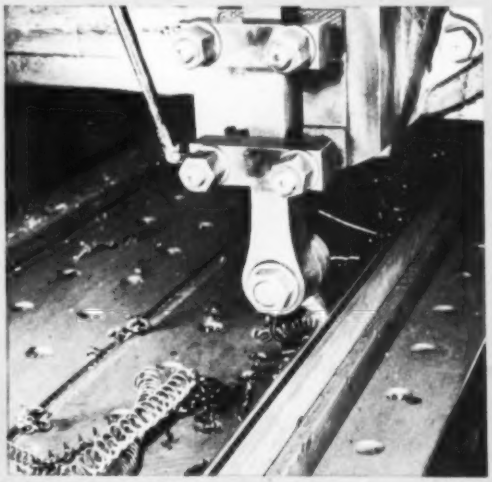
• • •

U·S·S Free-Cutting CARILLOY FC steel is a deep hardening Mn-Cr-Mo steel, already quenched and tempered to the hardness you require. You do not have to heat-treat after machining; you thus eliminate rejects caused by distortion and scaling.

CARILLOY FC is available now in all standard bar sizes. And remember, CARILLOY FC steel costs only a *fraction of a cent* more per pound than ordinary, through-hardening alloy steels.

If you would like to apply this pre-hardened and tempered free-cutting alloy steel to your production, write to United States Steel, Room 4328, 525 William Penn Place, Pittsburgh 30, Pa. Our representative will call.





USS

COLUMBIA-GENEVA STEEL . . . . TENNESSEE COAL & IRON . . . . UNITED STATES STEEL SUPPLY, WAREHOUSE DISTRIBUTORS

Divisions of UNITED STATES STEEL COMPANY, PITTSBURGH

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

"My crew is as good as

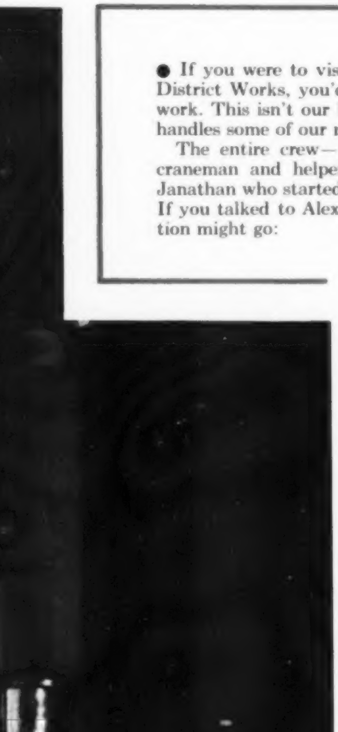
you can find"

says Alex Janathan,

U. S. STEEL PRESSMAN

● If you were to visit the forge shop at our Homestead District Works, you'd want to see the 7,000-ton press at work. This isn't our biggest press, or our smallest, but it handles some of our most interesting jobs.

The entire crew—press driver, manipulator operator, craneman and helpers are under the direction of Alex Janathan who started in the open hearth when he was 16. If you talked to Alex, here's about the way the conversation might go:



YOU: "*What did you do after you left the open hearth?*"

JANATHAN: "When I left the open hearth, after 3 years, I was first man on the ladle. Then I went to the Heat Treating and Forge Department and worked on the alloy plate shears for 3 years."

YOU: "*And you've stayed in the forge department ever since?*"

JANATHAN: "Yes, at different jobs. After working the shears, I went burning for 3 years—cutting locomotive side frames out of slabs. It was a new idea to replace castings. While I was burning, I got turns as helper on the 3,000-ton press. I worked as press driver, then in '34 was made pressman."

YOU: "*So you've been a pressman now for about 18 years. Did you work on other presses, too?*"

JANATHAN: "I've worked every press we own."

YOU: "*Do you specialize on any one type of product?*"

JANATHAN: "No. I make turbine and generator shafts, every kind of alloy and stainless steel forgings. I also make water wheel shafts, U-plates, half-circles, as well as drop hammer bases and columns."

YOU: "*What's one of your biggest problems while you're forging these big jobs? What do you have to watch for?*"

JANATHAN: "Well, there's the problem of ingots that don't cool evenly while they're on the press."

YOU: "*What causes that?*"

JANATHAN: "When the ingot comes from the furnace, it's evenly heated all the way through, but it's covered with scale. While we work it, sometimes the scale gets knocked off on just one side; so that side cools faster than the side that's insulated with scale. When we forge a piece like that, the hot, or scale side flows outward faster than the cool side, and the piece will not forge accurately."

YOU: "*What do you do then?*"

JANATHAN: "First, we try to remove scale evenly from the ingot. But if it still cools unevenly, we spray the hot side with water until the temperature is even all around. Then the ingot flows the same on all sides. Even ingot heat is awfully important. . . . If it cools too much, the corners start to tear, especially when you're forging alloy and stainless steels. These things are important because we work to such close tolerances. Take a 55" ingot. When we forge a die block bloom from that ingot we reduce it to 37" x 21" and only have ¼" tolerance."

YOU: "*As far as you're concerned, what's the most important factor in making good forgings?*"

JANATHAN: "First, you have to have good steel. We make our own so that's never a problem. Then you have to have good equipment. We've got the best. But most important is the crew. Mine for example. Turnover is small. Every man knows his job and has been on it for years. I've visited a lot of forge shops, but my crew is as good as you can find."

• • •

When you buy forgings from United States Steel Company, men like Alex Janathan and his crew work on them. We'll match their skill against the best in the land. For more information on U·S·S Quality Forgings, write to United States Steel Company, 525 William Penn Place, Pittsburgh 30, Pa.

STEEL

USS

Quality

FORGINGS

- forged bars, billets, blooms
- electrical and water wheel shafts
- hammer bases and columns
- marine forgings

Facts you should know about U·S·S CARILLOY STEELS

U·S·S CARILLOY BORON STEELS PROVE EFFECTIVE IN CONSERVING "CRITICAL" ALLOYS

Today American industry is faced with the unpleasant fact that, after military needs are met, there is not nearly enough nickel and molybdenum available to produce steels containing these alloys. Actually the alloy shortage is worse now than in World War II.

However, insofar as heat treating steels are concerned, the picture is not as grim as it might be. For in the last war, the potentialities of the element boron for increasing the hardenability of steel became widely recognized and thousands of tons of boron steels were produced by United States Steel and used in military equipment, such as armor, projectiles, torsion springs for tanks, etc.

These and post-war applications of boron steels in large diesel locomotive crankshafts, heavy-duty tractor axles, in wrenches and hand tools, have thoroughly demonstrated boron's ability to replace several hundred times its own weight of other hardening alloys such as nickel, chromium, molybdenum and manganese. Not only have boron steels helped to conserve these critical alloying elements, where they are necessary only for adequate hardenability, but they have effected considerable savings both in the cost of steel and in fabricating costs as well.

U·S·S SuperKore—a pioneer boron steel

More than six years ago, United States Steel Company developed U·S·S SuperKore A, which is essentially a 4312, plus boron and 0.03/0.07% vanadium. Used by a leading aircraft engine builder, this steel (designated as TS 43BV12) has successfully replaced 3310, in heavy-duty gears, shafts and pinions for large air-cooled reciprocating engines and is approved for aircraft use under AMS Spec. 6266. Not only does SuperKore A save one-half the nickel and two-thirds the chromium formerly required but the manufacturer reports improved carburizing characteristics—with less retained austenite and fewer undissolved carbides on direct quenching.

Similarly, U·S·S SuperKore AA—a 4315 plus boron—shows improved hardness near the surface and large tonnages have been used by a leading heavy-duty truck builder who reports that transmission countershafts made from it have been in service for five years with excellent results. Used to replace 4800 types, this steel now designated as TS 43BV14 reduces nickel and molybdenum requirements by one-half.

Another U·S·S SuperKore Steel—SuperKore B—which is a 4615 plus boron, designated TS 46B12, has been successfully used for more than three years to replace 4812, in making a famous line of rock bit cutters, and saves one-half the nickel formerly required.

U·S·S SuperKore C—a 8615 plus boron—originally developed to replace 4300 carburizing grade, and which reduces nickel by one-half and molybdenum by one-fifth has shown good results.

Our work on these alloy-saving carburizing steels has shown that lower alloy steels containing boron will have the same core properties as the higher alloy steels they match in hardenability. In addition to conserving critical alloys they (1) improve hot and cold working, (2) require a shorter annealing cycle, and (3) have improved machinability. All these factors result in fabricating economies.

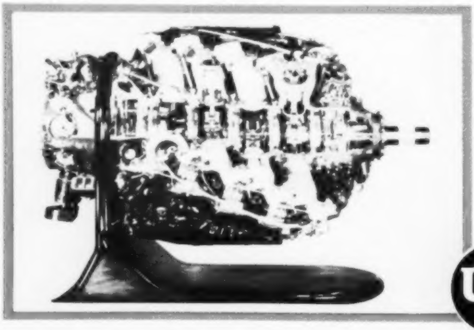
Because in some cases boron steels require more care in their selection and treatment than do the conventional alloy steels, we offer you the assistance of our metallurgists who have pioneered their development and whose practical cooperation will be of material benefit in applying boron steels to your equipment. Simply write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa., Room 4328.

There are other approaches to the alloy problem

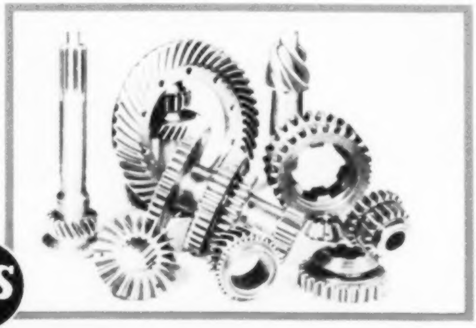
Although the substitution of boron steels for standard alloy grades has enabled many customers to meet their requirements, such substitution is only one of the ways our metallurgists and research specialists are able to solve today's alloy problems.

For example, in some cases, emergency alloys, without boron, have proved entirely satisfactory. In others, improved heat treating procedures have provided adequate hardness and other physical properties in lean standard alloy steels.

In addition to the use of U·S·S SuperKore A in this engine, SuperKore steels are being used in other aircraft power plants.



Heavy-duty truck transmission gears and rear differential gears and pinions such as these are made of U·S·S SuperKore AA.



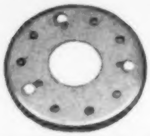
COLUMBIA-GENEVA STEEL . . . . TENNESSEE COAL & IRON . . . . UNITED STATES STEEL SUPPLY, WAREHOUSE DISTRIBUTORS

Divisions of UNITED STATES STEEL COMPANY, PITTSBURGH

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

TYPICAL RESULTS OF BRIGHT, SCALE-FREE WORK THE "IPSENWAY"



1. CLUTCH PRESSURE PLATE
Carbonitrided, 300 per heat, to case depth of .005"—.007" in cycle time of 60 minutes.

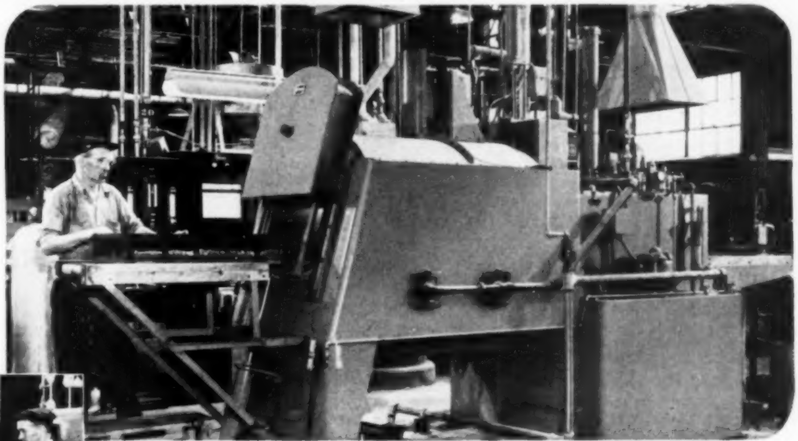
2. BREATHER VALVE GEAR
Carbonitrided, 250 pieces per heat, to case depth of .010"—.012" in cycle time of 95 minutes.

3. FENDER HINGE SEGMENT
Carbonitrided, 750 pieces per heat, to case depth of .010"—.012" in cycle time of 90 minutes.

4. ROLLER TAPPET ASSEMBLY
Carbonitrided, 800 pieces per heat, file hard case, in cycle time of 60 minutes.

PRODUCTION SHORT-CUTS *in Heat Treating*

AT HARLEY-DAVIDSON MOTOR CO., MILWAUKEE



View of Ipsen T-250 Unit in operation at Harley-Davidson. Loading door is hydraulically operated by foot pedal. Trays are transferred from heat through intermediate door into quench or cooling chamber automatically.

Unloading view showing parts after oil quenching operation. Oil is automatically circulated and temperature controlled, assuring uniform cooling throughout load.

...with an IPSEN Standard

AUTOMATIC HEAT TREATING UNIT

Illustrated above are typical heat treating results obtained by Harley-Davidson Motor Co., Milwaukee, in processing parts automatically in a standard Ipsen Heat Treating and Quenching Unit. Individual methods are applied for each part to suit material and depth of hardness desired. The operation in the Ipsen is automatically controlled from heat through quench (or cooling) so that highly uniform, dependable results are obtained from batch to batch.

Acid Cleaning and Extra Handling Eliminated

Because each load is heat-treated at a uniform temperature and in a controlled and sealed atmosphere condition, the work comes out bright and scale-free. This, in turn, eliminates acid cleaning operations and extra handling. In addition, clean working conditions prevail, and unskilled operators can be quickly and easily trained to tend several units simultaneously. Investigate this modern, simplified method of heat treating today.

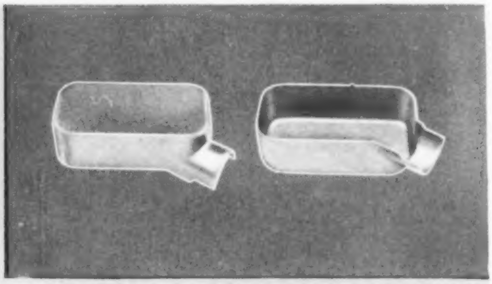
THE AUTOMATIC Ipsen HEAT TREATING UNIT

Write **TODAY FOR MORE FACTS**

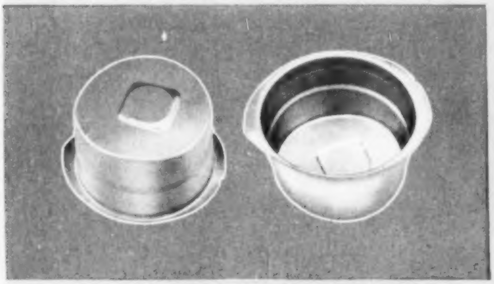
Ask for free bulletins and find out how Ipsen Units can be applied to your work. If you wish, samples of your work will be run, procedures established, and production estimates made without obligation.

IPSEN INDUSTRIES, INC., 723 South Main Street, Rockford, Illinois
Production units for CARBONITRIDING · CARBURIZING · HARDENING · BRAZING · MARTEMPERING

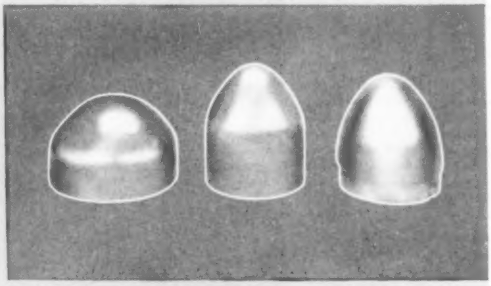
Part for smokeless powder ammunition powder tank formed from blank of .090 gage—3 SO Aluminum and ironed in the draw so that sides come to .051 gage. Impossible to make before use of Johnson's No. 150 Wax Lubricant. Now draw and iron in one operation.



Automobile front defroster case (.0299 Al. Kiln Steel) made in 4 draws without annealing. One application of Johnson's No. 150 Wax Lubricant prior to 1st draw sufficient for all draws plus 3 blanking and trimming operations. Conventional lubricants caused tearing at hose neck connection and required annealing before 5th draw.



Truck heater case (.0299 cold rolled steel) drawn with Johnson's No. 150 Wax Lubricant after unsatisfactory results with other lubricants. Use of No. 150 resulted in far less heat in the draw—permitted use of dies with closer tolerances—reduced wrinkling and tearing—produced perfect draws—cleaned up entire operation.



Nose of demolition shell. With conventional lubricant required 4 progressions to form the shape—8 to complete it. Necessary to alter die 3 times to produce 2,000 units. Use of Johnson's No. 150 Wax Lubricant reduced operation to 5 steps (blank and form—turn form—notch and form neck—spin—trim) and produced better than 15,000 units with no die alteration necessary. No application of lubricant is required after initial application.

MORE "IMPOSSIBLE" DRAWS WITH NEW JOHNSON'S WAX LUBRICANTS

Johnson's Wax Lubricants for drawing and stamping metal are giving results unobtainable with conventional lubricants.

Every day, more proof of this becomes available. It comes from manufacturers who have successfully used these revolutionary new *wax* lubricants to perform previously "impossible" draws.

Johnson's Wax Lubricants permit unhampered flow of the metal during the draw to produce smooth, gall-free surfaces and perfect angles, corners and curves. They are unmatched for drawing, stretch forming, bending, reducing, swaging, coining and lamination stamping.

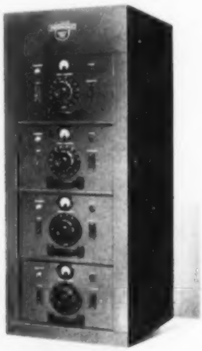
Test these new wax lubricants in your own shop—at our expense. Write for free sample and complete information concerning the use of Johnson's Wax Lubricants for your specific jobs. S. C. Johnson & Son, Inc., Industrial Products Department, Racine, Wisconsin.

A Product of JOHNSON'S WAX Research

Engineering Digest

OF NEW PRODUCTS

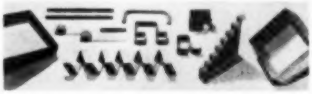
INDUCTION HEATER STATIONS: Multiple 2½-kw. units, combined in a single cabinet, are now available for general-purpose induction heating applications. Individual units can be removed and replaced, similar to a drawer of a filing cabinet. It also fills the need between the existing low-power and high-power machines. The 2½-kw. machine, Model 100S, is available from its manufacturer, the Induction Heating Corp., in a number of heavy-gage steel cabinets, in any combination. They may be in the form of heating sections and power supply in one cabinet, or the heating



section may be remotely located from the power section. Any number of multiple power supply units are available in one cabinet to supply power to the heating station, which can be located at any convenient point on the production line. Input requirements per section are 4 kva. at 220 volts, 60 cycles, single phase.

For further information circle No. 213 on literature request card on p. 32B

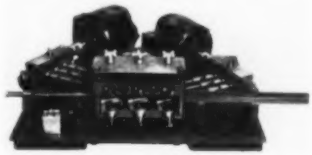
FORMING MACHINE: A new model "Bendit" metal forming machine is announced by Kilham Engineering, Inc., with capacity to bend 15 in. of 18-gage mild steel or equivalent. This machine forms sheet, strip and rod stock and small tubing into innumerable complex as well as simple shapes. The manufacturer states that the machine will form any desired radius from 1/32 to ⅝ in. and will make boxes up to 15x15x5 in. Bends of any angle, including complete folds and partial bends can be made. The machine was developed primarily for short-run production work, such as forming aircraft components. It eliminates the need for expensive dies and



intricate tooling, is provided with positive stops and gages for accurate duplicating, is open ended front and back for feeding long strip stock.

For further information circle No. 214 on literature request card on p. 32B

ROTARY STRAIGHTENER: Model AYZ rotary straightener is now being manufactured by Mackintosh-Hemphill Co. for industries that need to remove waves, bends and kinks from cut lengths of 1/16-in. rod or thin-wall tube up to ¼-in. o.d. The new model has three sets of identically contoured twin cross rolls, all power driven. In practice, the middle pair of rolls is adjusted up or down so that the correct amount of offset is



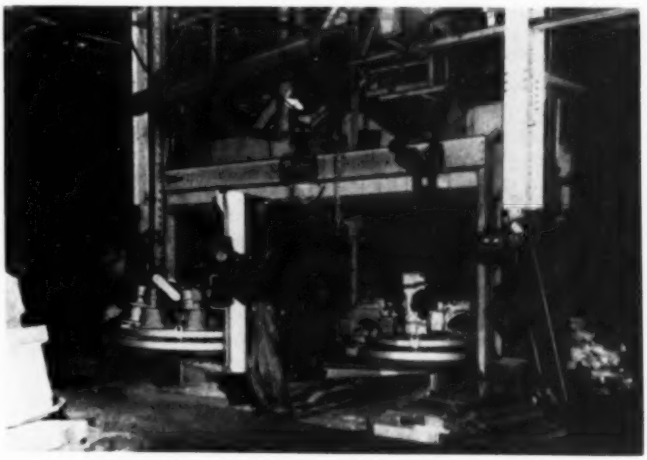
maintained. Stock as short as 6 in. can be straightened. Operating speed on rod or tube is 100 ft. per min. The machine has met a straightness specification of 0.005 in. in 2 ft. of ⅛-in. alloy bar stock.

For further information circle No. 215 on literature request card on p. 32B

LOW-MAGNIFICATION STRAIN INSTRUMENTS: Tinius Olsen Testing Machine Co. offers a new line of low-magnification strain instruments. The C-1 instrument has three magnifications, of 10, 20, 40; the C-2 provides magnifications of 1, 2, 4; the C-3 has 2½, 5 and 10. When used in conjunction with the S-type extensometer, complete stress-strain curves

BLAST CLEANING: A new "Turnstyle" table, by Pangborn, is used at Farrell-Cheek Steel Co. to blast large castings up to 6½ ft. long, 5 ft. high and 1500 lb. The abrasive is hurled against the work as it is passed under the abrasive-throwing "wheel". Work is placed on tables attached to each side of the door of the cleaning room. The door turns about a center axis in such a manner that the operator loads one table with up to 1.5 tons of castings while the other table is inside the room under the cleaning stream. With this arrangement the cleaning machine bombards castings 85% of the time, being stopped only to turn the door. Green work is blasted 8 min. and annealed castings 12 min. The machine averages 40 to 50 loads per 8-hr. day and by eliminating older hand cleaning methods has cut labor costs by 22%, or $8.50 per day.

For further information circle No. 216 on literature request card on p. 32B



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Tension test on Riehle 120,000 lbs. Hydraulic Universal. Photo courtesy Cleveland Tank Plant, Cadillac Motors Corp.

Only Riehle Universal Testing Machines give you 5 SCALE RANGES — the equivalent of 5 separate testing machines in one. 5 scale ranges provide complete coverage of the machine's full capacity and permit you to select the one range most applicable for any given test. Each range is covered by a single revolution of the dial pointer.

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Model	Range 1 From 0 to	Range 2 From 0 to	Range 3 From 0 to	Range 4 From 0 to	Range 5 From 0 to
PH-10	10,000	5,000	2,500	1,000	500
PH-20	20,000	10,000	5,000	2,000	1,000
PH-30	30,000	15,000	6,000	3,000	1,500
PH-60	60,000	30,000	12,000	6,000	3,000
PH-120	120,000	60,000	30,000	12,000	6,000
PH-200	200,000	100,000	50,000	20,000	10,000
PH-300	300,000	150,000	60,000	30,000	15,000
PH-400	400,000	200,000	80,000	40,000	20,000

CONSTANT ACCURACY — Riehle Universals are guaranteed to be within one half the normal tolerance allowed by ASTM and Federal specifications.

SINGLE DIAL CONTROL — One dial controls speeds for the complete testing cycle, from fast forward to fast return.

LOW TABLE AND GRIPPING HEAD — Provide easy access to testing tools and specimens.

EASY TO INSTALL — Riehle Universals are floor level units, requiring no installation pits.

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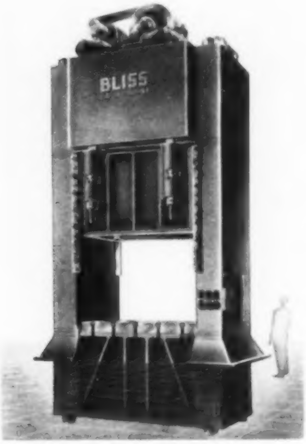
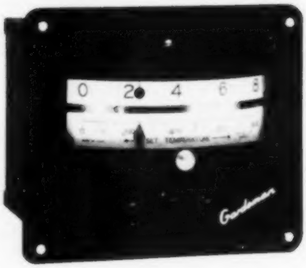
may be produced automatically without stopping tests. Used to detect large motions of specimen deformation in tension, compression and flexure testing, C-type instruments transmit signals by means of differential transformers which rotate the recorder drum in direct proportion to the motion measured (usually crosshead differential travel).
For further information circle No. 217 on literature request card on p. 32B

DRAWING PRESS: A new series of four-point, double-action, toggle-drawing presses featuring quick advance and return speeds has been developed by E. W. Bliss Co. The new presses are specially designed to meet the needs of the automotive and allied industries by making possible higher production rates for large-area, drawn stampings. Greater production rates have been made possible through use of the eddy current



clutch, which provides for quick approach to the work, slow-down to give proper drawing speeds, and quick return speed to the top of stroke. Even with comparatively slow drawing speeds, a rapid press cycle is possible. The slow-down is accomplished by controlled slippage of the eddy current drive clutch through limit switches which can be adjusted to vary the speed of any portion of the draw cycle.
For further information circle No. 218 on literature request card on p. 32B

TEMPERATURE CONTROLLER: A proportioning, indicating pyrometric controller in the same price range as regular off-on indicating controllers is now being manufactured by the Taco West Corp. The proportioning controller is so called because it



automatically adjusts the ratio of "on" and "off" over a given time-cycle to maintain any desired temperature set with the index pointer. This results in a "straightening out" of the temperature control curve.
For further information circle No. 219 on literature request card on p. 32B

STEEL FOR DIE-CASTING DIES: The Carpenter Steel Co. has announced a die steel 50 to 60% as easy to hob as soft hobbing irons and having high strength and resistance to heat and abrasion. Known as "Super Samson", the steel has a nominal composition of 0.10% carbon, 5% chromium, 0.90% molybdenum, 0.25% vanadium. It was developed primarily for die casting of aluminum and zinc. It is also being used successfully in plastic mold work involving large cavities or elevated temperatures. It will harden uniformly in dies with wall thicknesses up to 4 in. and company metallurgists predict it will make possible greater use of hobbing for large or intricate die cavities.
For further information circle No. 220 on literature request card on p. 32B

IMPREGNATING EQUIPMENT: A new machine for production-line impregnating of castings has been announced by Metallizing Co. of America. This unit, called the M-30 Mogullizer, is designed to help overcome the present material shortage

by sealing both leaking and weeping castings — ferrous and nonferrous — under a high vacuum. Placed in the unit's sealing tank, castings are first subjected to a 29½-in. vacuum for 20 min., removing all air and moisture from their inner walls. Next, an impregnating solution is introduced into the vacuum tank covering the castings. This is followed by application of 100-lb. air pressure for another 20 min., forcing the solution into the casting walls from all directions.
For further information circle No. 221 on literature request card on p. 32B

QUENCH TANK: A new quench tank introduced by A. D. Alpine, Inc., is designed to receive work from a mechanical loader which removes the entire load from the furnace and quenches it in one operation. The quench tank maintains a constant level regardless of the displacement caused by treated work: As the load is lowered into the tank, the overflow

runs into the reserve section of the tank. In this section is a heavy-duty pump which circulates the liquid back into the main part of the tank, aerating and cooling the liquid to insure a uniform quench.
For further information circle No. 222 on literature request card on p. 32B

CORROSION-RESISTANT COATING: A new material with superior corrosion-resistant properties has been developed by Detrex Corp. for coating the inside of their solvent-vapor degreasers. This non-porous, phenolic-type coating, Detrex FF-1, is remarkably impervious to any dissolving effect by trichlorethylene and perchlorethylene. It is also strongly resistant to any chemical breakdown that might be caused by water-solvent mixtures, and relatively strong solutions of acids and alkalies and their vapors. Machines coated with FF-1 have been production tested for several years under severe operating

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This book is a complete and compact library of brazing data that every design and production engineer—every brazing technician and buyer of brazing materials should have! It is the most complete guide you can get to all aspects of silver brazing applications and problems.

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conditions without any sign of failure, showing service life comparable with that of machines fabricated from much more expensive nickel-clad steel.
For further information circle No. 223 on literature request card on p. 32B

RESISTANCE THERMOMETERS: A new line of resistance thermometers designed for accurate indication and control of temperatures ranging from minus 100° F. to plus 300° F.

has been announced by General Electric Co. The new instruments, applicable in a wide variety of industrial processes, are available in three basic types: the HP-11 resistance-thermometer indicator; the HP-13 two-position controller or protector; and the HP-14 three-position controller. All the thermometers use the same basic mechanism, a crossed-coil moving element and a high-strength 3¼-lb. Alnico 5 magnet.
For further information circle No. 224 on literature request card on p. 32B

CLEANING ALUMINUM: A nonfoaming, noncorrosive, nonetching aluminum hot tank cleaner that rinses quickly and completely with no tendency to bake on or leave a powdery residue is the newest addition to the family of Turco Products. Formulated for use in the aircraft industry, the new product is called "Aviation". The new cleaner, which meets the corrosion requirements of MIL-C-5543, quickly removes all types of foreign matter — even hard-to-remove etching-type marking ink and will not etch or darken even a highly polished aluminum.
For further information circle No. 225 on literature request card on p. 32B

SILICON IRON: Thomas and Skinner Steel Products Co. announces the introduction of OrthoSil, a new 4-mil iron-silicon material for laminations, designed especially for high-frequency inductors. These laminations have exceptionally high permeabilities, from very low to very high inductions,

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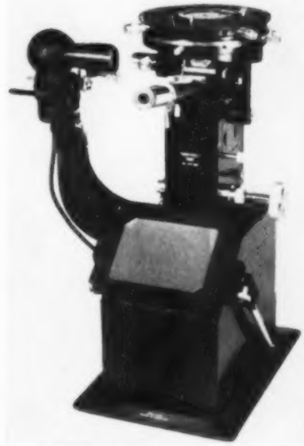

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They like OSTUCO Tubing for flexibility in design, great strength, light weight, good machinability, smooth finish, high quality, low cost.

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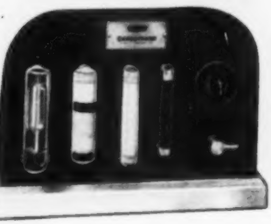
with correspondingly low core losses. OrthoSil is oriented to provide directional magnetic characteristics, and was developed primarily for frequencies of from 400 to 2000 cycles. This new product is also readily adaptable to the audio ranges.
For further information circle No. 226 on literature request card on p. 32B

CARBON DETERMINATION: Burrell Corp. has introduced the Carbotrane, a new unit-package train for improved gravimetric determination of carbon by combustion. It is a compact arrangement of throw-away and quickly replaceable glass cartridges containing commonly used reagents



and may be used with either resistance or high-frequency combustion furnaces. When used with high-frequency combustion furnace the built-in timer shuts off the power to the reaction coil. Absorption tubes are of uniformly prepacked cartridge-type, easily replaced.
For further information circle No. 227 on literature request card on p. 32B

PHOSPHATE COATING: Keynote is a new material developed by Kelite Products, Inc., to phosphatize steel and iron at low concentrations. A finely powdered material, it operates in pH range as low as 3. No stainless steel equipment is required when this material is being used. It can be applied by either spray or immersion. It can be rinsed if called for but this is not necessary. Normal immersion is 1 to 2 min. Longer periods will not improve the coatings.
For further information circle No. 228 on literature request card on p. 32B

ELECTRON MICROSCOPE: A new electron microscope (EM-100) is now available from North American Philips Co. Screen magnification is continuous from 1000 to 60,000 × and the instrument is capable of producing micrographs of 30 Angstroms resolution or better. The microscope has a beam oscillator for rapid determination of exact focus, eliminating the necessity for a series of exposures with conjunctive time loss. The large

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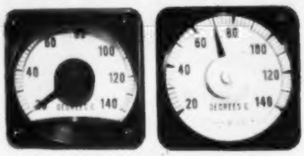
Routine inspections of new General Electric Type HP pyrometers can quickly be made. Besides making preventative maintenance easy, this equipment has many other features to provide accurate indication and temperature control of furnaces, ovens kilns, and other industrial heating equipment.

ACCURATE WITHIN ¾ OF 1% full scale, HP-3 pyrometers have automatic cold-junction compensation that adjusts for changes in ambient temperature.

Any change in temperature, even as small as 0.1% full scale, starts immediate control action. Normal changes in humidity, ambient, and voltage have little or no effect on the exactness of control action.

FOUR TYPES AVAILABLE—indicating, protecting, two- and three-position control forms; also both flush and surface mountings. All available in a variety of temperature ranges in the 0-3000 F span.

Mail the coupon for complete information about Type HP pyrometers.



OLD NEW

New Shadow-proof Temperature Indicators Are Easier to Read

Temperatures from −100 F to +300 F can now be accurately indicated and controlled with General Electric's new line of temperature indicators. These instruments can be read from almost any angle. The dial is set forward, flush with the front of the case. A protruding convex-type glass front provides clear illumination. No more cover overhang; no more shadows caused by overhead lighting. Two sizes available—4¼- and 8¾-inches. Check coupon.

New Resistance Thermometers Accurately Indicate and Control Low Temperatures

TEMPERATURES FROM −100F to +300 F can now be accurately indicated and controlled with General Electric's new line of resistance thermometers. They indicate accurately within ¾ of 1 per cent full scale. Any change in temperature equivalent to 1/10 of 1 per cent full scale starts immediate control action.

Normal changes in humidity or room temperature do not affect the exactness of control. Neither does a change in control voltage. Sturdy, simple construction assures reliable operation under severe operating conditions.

NARROW TEMPERATURE SPANS, as small as 90 degrees, are available anywhere in the −100 F to +300 F range. You can buy four types of resistance thermometers—indicators, protectors, and two- or three-position controllers for either flush or surface mounting.

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- ☐ Resistance Bulb (GEC-835)
- ☐ Type HP-3 Pyrometer (GEC-713)
- ☐ Temperature Indicators (GEC-218B)
- ☐ Thermocouples, Accessories (GEC-714)
- ☐ Thermocouple Potentiometer (GEC-245)

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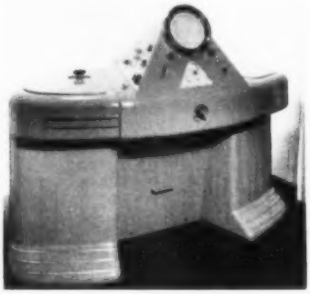
field permits recording in a single photograph, areas which might otherwise require a mosaic of six individual sections. A roll film camera is employed, using standard 35-mm. high-contrast film, permitting up to 40 exposures at one loading. Positioning and film transport is effected instantaneously while under vacuum, and partial exposure of the magazine is possible. A built-in photometer provides a standard for proper exposure time. A plate camera is available as an optional accessory.



Immediate change-over for electron diffraction patterns of preselected portions of the specimen is possible without change of pole pieces, specimen transferral or re-evacuation. The particle from which the pattern is to be derived is under continuous observation up to the moment the pattern appears, assuring its identity. **For further information circle No. 229 on literature request card on p. 32B**

D-C ARC WELDERS: The new Model GA "Wasp" direct-current arc welders, available in 150 and 200 amp. sizes, have been announced by Air Reduction Sales Co. The volt-ampere characteristics of these machines make them especially suited to d-c. straight-polarity Heliwelding. Continuous overlap from each current range to the next provides a wide, unbroken range of welding current — 30 to 250 on the 200-amp. welder and 20 to 185 on the 150-amp. machine. **For further information circle No. 230 on literature request card on p. 32B**

SURFACE-ACTIVE AGENT: Alrose Chemical Co. has announced a sodium alkyl naphthalene sulfonate surface-active agent for use in soak cleaners of the sodium phosphate or metasilicate types and various acid cleaners. Known as Sorbit, the agent makes it possible to skim soil and debris from the surface of the bath, keeping contamination at a minimum. **For further information circle No. 231 on literature request card on p. 32B**

Kemp Immersion Melting Pots won't CRACK or BREAK

Save up to 40% on fuel with greater heating surface, faster heat recovery

More and more plants depend on Kemp Immersion Heating for *continuous, trouble-free* performance. Kemp pots, unlike underfired pots, can be used steadily in annealing, coating, tempering, descaling, etc. ...without the threat of *periodic* and *expensive* shutdowns for breakage. And each new Kemp installation means you eliminate costly temperature override, dangerous open flame fire hazards and the clutter of unsightly external pipes and ducts.

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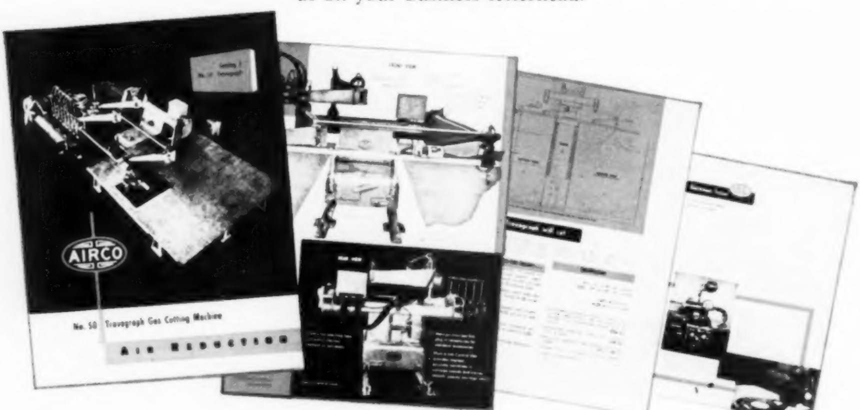

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What's New

IN MANUFACTURERS' LITERATURE

232. Abraser

Bulletins illustrate and describe a durable precision instrument for evaluating the resistance of surfaces to rubbing abrasion. Also several specimen holders for use with abraser. *Taber Instrument Corp.*

233. Abrasive Wheels

Data folders give operating suggestions and recommended grades of abrasive wheels for stainless alloys, for finishing and semi-polishing and other applications. *Manhattan Rubber Mfg. Div., Raybestos-Manhattan, Inc.*

234. Alloy Steels

New 16-page, pocket-size booklet contains seven case histories selected from widely varied fields to demonstrate the versatility of alloy steels. *Republic Steel Corp.*

235. Aluminum

"Aluminum Progress" tells of the many applications of aluminum. *Reynolds Metals Co.*

236. Aluminum

"Alcoa Aluminum Impact Extrusions" gives information on impact extrusion process and service. Shows range of shapes for engineering. *Aluminum Co. of America.*

237. Analysis

New, 20-page working manual on electro-analysis apparatus for copper and lead contains methods of use and extensive bibliography. *Eberbach Corp.*

238. Anodizing Racks

Folder gives data on aluminum racks with copper hooks, insulated for any anodizing solution. *National Rack Co., Inc.*

239. Anti-Carburizing Paint

Descriptive literature is available on paint which prevents carburizing or hardening of certain spots on steel parts. *Case Hardening Service Co.*

240. Blowers

Bulletin No. 300-S illustrates, diagrams and informs concerning a new constant pressure turbo blower and properly selected piping. *North American Manufacturing Co.*

241. Brazing

50-page text GEA-3193 describes the methods and applications of electric-furnace brazing. *General Electric Co.*

242. Bronze Castings

Paper on effects of superheating 85-5-5-5, 88-8-4 and 80-10-10 alloys, with tables and graphs showing physical property changes. *R. Lavin & Sons, Inc.*

243. Burners

Full details on high thermal release burner, unit intended for use where quick heating and intense concentration of heat are desired. *Bloom Engineering Co., Inc.*

244. Camera Microscope

Complete information on construction, operation and special features of MEF universal metallurgical camera microscope. *Wm. J. Hacker & Co., Inc.*

245. Carbon Control

Catalog T-623 describes the Microcarb control system that continuously measures the active carbon in the furnace atmosphere during heat treatment. *Leeds & Northrup Co.*

246. Carbon Determination

Bulletin 323 describes new package-unit carbon train with cartridge-type disposable absorption tubes. *Burrell Corp.*

247. Case Hardening Compound

Technical data on Aerocase, case hardening compound. *American Cyanamid Co.*

248. Castings, Heat Resistant

4-page bulletin describes heat resistant castings produced in designs for a wide variety of applications, including conveyors, roller hearths, trays, and radiation tube assemblies. *Standard Alloy Co.*

249. Castings, Stainless Steel

8-page folder tells how intricate stainless steel castings were turned from problem castings into large-scale production jobs. *Cooper Alloy Foundry Co.*

250. Cleaner

Product information folder gives data on industrial metal cleaners for use with water in either still tank or spray washing equipment. *Solventol Chemical Products, Inc.*

251. Cleaner

Technical specifications for surface active agent used with both acid and alkaline cleaners. *Alrose Chemical Co.*

252. Cleaner

Bulletins on Virgo descaling salt and Virgo molten cleaners. What they are, how they work, their advantages and how they fit into your operations. *Hooker Electrochemical Co.*

253. Cleaner

Bulletin 74-15 gives data on all-electric steam detergent cleaning. Pressures to 200 psi. *Livingstone Engineering Co.*

254. Cleaning

Data on Aja-Lif equipment for removal of buffing compounds, chip removal, quenching and other cleaning operations. *Magnus Chemical Co.*

255. Cleaning

New booklet entitled "Your Metal Rearmament Products" contains outline of most efficient methods of handling, as well as cleaning, metal products for defense. *Alvey-Ferguson Co.*

256. Cleaning

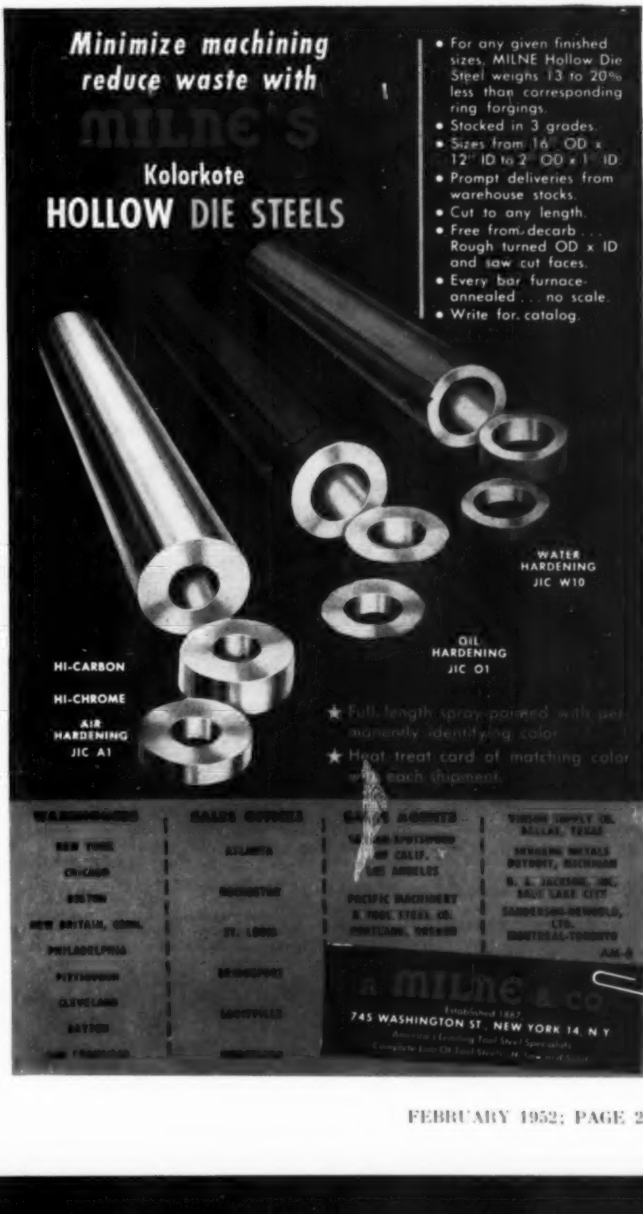
Bulletin 214 gives full details, specifications and actual performance on faster blast cleaning with Rotoblast barrels. *Pangborn Corp.*

257. Cleaning Equipment and Materials

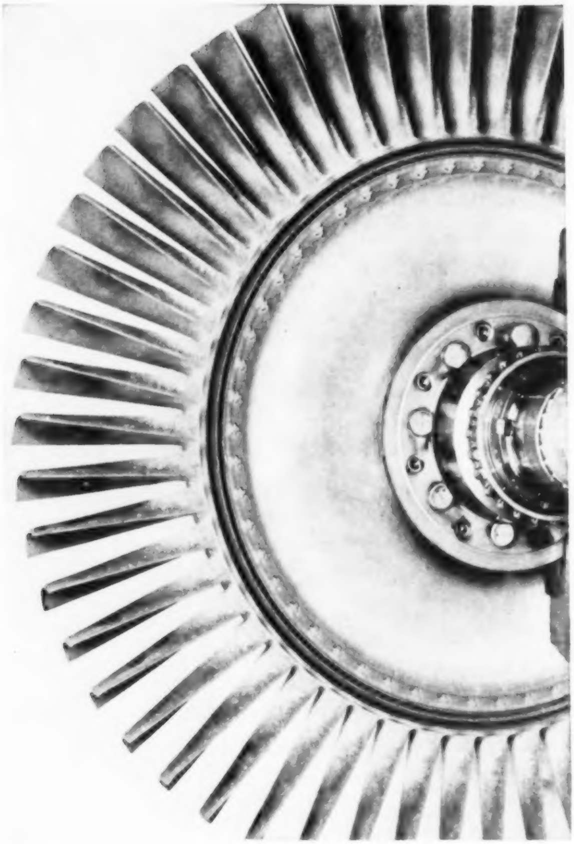
Series of attractively illustrated bulletins informs concerning dry cleaning process, degreasers, metal parts washers, degreasing solvents, emulsion and alkaline cleaners and rust proofing compounds. *Detrex Corp.*

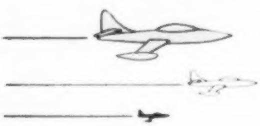
258. Coatings

Information on Bonderite, nonmetallic coating which is resistant to corrosion and a good paint base. *Parker Rust Proof Co.*



UTICA HELPS





BY FORGING EXTRA "*FIGHT*" INTO TURBINE BLADES

Here's the turbine assembly of Pratt & Whitney Aircraft's great J-42 Turbo-Wasp—first jet engine to attain official rating for 1,000 hour overhaul.

Take a particular look at the turbine blades, photographed after 500 hours of actual operation. Besides contributing to the general service dependability of the J-42, they have another remarkable story all their own.

Combat pilots in Korea report that these blades, operating at 12,000 rpm and at extremely high temperatures, have taken damage from bullets and rocks without serious impairment of engine performance — and brought plane and pilot safely back to base.

The forging of rugged blades like these is the type of work we're doing here at UTICA. We're proud that UTICA was one of the earliest primary suppliers of turbine blades to Pratt & Whitney Aircraft for the Turbo-Wasp.

U TI CA

UTICA DROP FORGE & TOOL CORPORATION, Utica 4, New York

259. Compression Testing

Brochure 521 describes and illustrates compression testing machines and accessories. *National Forge & Ordnance Co.*

260. Compression Testing

Four-page folder on machines for compression testing of sheet metal, rivets, springs, welds. *Labquip Corp.*

261. Controlled Atmospheres

Bulletin available on new Alnor Dewpointer for accurate, consistent reading of atmosphere in field and laboratory. Readily portable, operating on AC or enclosed battery. Furnished in three ranges between 20° F. and room temperature, from minus 100° F. to 0° F. and from minus 80° F. to room temperature. *Illinois Testing Labs.*

262. Copper Alloy Tubes

An extensively illustrated 32-page brochure deals with causes of corrosion and means of combating them as well as choice of materials for condenser tubes. *Revere Copper & Brass, Inc.*

263. Copper Alloys

Illustrated, 24-page publication, B-14, on rods for screw machine use includes physical constants and properties of 46 free-cutting and general-purpose rods. *American Brass Co.*

264. Corrosion-Inhibiting Metal Waxes

Data sheet of physical characteristics and application methods for solvent-type and emulsion-type metal waxes for protective finishes. *S. C. Johnson & Son, Inc.*

265. Cut-Off Wheels

6-page folder gives data, operating suggestions and grade recommendations of cut-off wheels for delta machines. *Manhattan Rubber Div., Raybestos-Manhattan, Inc.*

266. Cutting Oil System

Illustrated booklet gives data and charts on new cutting oil, dispensing jet and motor driven pump. Contains test results of overhead flood with conventional coolants vs. new twin development. *Gulf Oil Corp.*

267. Degreaser

Vapor degreaser OPNT described and diagramed in folder. Data on different models. *Topper Equipment Co.*

268. Die Casting Machines

Copies of "Lester Press" describe various features of aluminum die casting machines. *Lester-Phoenix, Inc.*

269. Dipping Baskets

Catalog B-7 illustrates and describes various kinds of dipping baskets and other processing carriers. *Rolock, Inc.*

270. Drum Cleaning

6-page, two-color brochure on fast, low-cost drum cleaning. Illustrated. *Pangborn Corp.*

271. Electric Furnaces

Illustrated brochure gives data on electric heat treating furnaces, melting furnaces, metallurgical tube furnaces, research furnaces and sintering furnaces. *Pereny Equipment Co.*

272. Electric Ovens

Data sheet displays new industrial portable high temperature electric ovens. Illustrated. *Grieve-Hendry Co., Inc.*

273. Electric Salt Bath Furnaces

Illustrated folders give data on salt bath furnaces for batch-type work and conveyorized-type work. *Upton Electric Furnace Co.*

274. Electrode Holders

Data sheets illustrate and describe complete line of electrode holders. Include price lists. *Wagner Manufacturing Co.*

275. Electron Microscope

Specifications for new Philips electron microscope EM-100. *North American Philips, Inc.*

276. Ferro-Alloys

"Electromet Products and Service" gives helpful information about the use of ferro-vanadium and other alloying metals. *Electro Metallurgical Co.*

277. Forming

Function, economics, scope and mechanics of cold roll forming are discussed in 86-page illustrated book. *Yoder Co.*

278. Forming

Special bulletin of metal spinning, stamping and fabricating facilities. *C. A. Dahlin Co.*

279. Forming Machine

Catalog and specifications for forming machine developed for short-run production work where the cost of dies would be prohibitive. *Kilham Engineering, Inc.*

280. Furnace Maintenance

A "Maintenance Guide for Electric Heat Treating Furnaces" describes preventive maintenance program for electric furnace users. *Hevi Duty Electric Co.*

281. Furnaces

16-page booklet "Proven Heat Treating Efficiency" containing attractive four-color illustrations displays complete line of furnaces. *Loftus Engineering Corp.*

282. Furnaces

Bulletin 435 describes new furnaces for tool room, experimental or small batch production. Gas, oil, electric. Muffle or direct heated. *W. S. Rockwell Co.*

283. Furnaces

Folders describe chain belt conveyor furnace, radiant tube gas heated, oil or electrically heated, other production furnaces. *Electric Furnace Co.*

284. Furnaces

Folder describes and illustrates tubular furnace for use in tensile testing and control panels. *Marshall Products Co.*

285. Furnaces

Bulletin IND-741 describes laboratory furnace for determining production heat treating schedules. *Hevi Duty Electric Co.*

286. Furnaces

Production electric heat treating furnaces are described in bulletin 1051. Types include those for continuous brazing and sintering, bright annealing, forging and general heat treating. *Harper Electric Furnace Corp.*

287. Furnaces

Illustrated bulletin available with complete description of new controlled atmosphere furnace. *Industrial Heating Equipment Co.*

288. Furnaces, Melting

Catalog on Heroult gantry-type electric melting furnace with patented roof-ring to assure speedy and simple bricking and eliminate skew shapes. *American Bridge Co.*

289. Gages

Bulletin BG-MP describes highly accurate beta radiation gage used for thickness measurements. One model measures thickness of material accessible from one side only. *Tracerlab, Inc.*

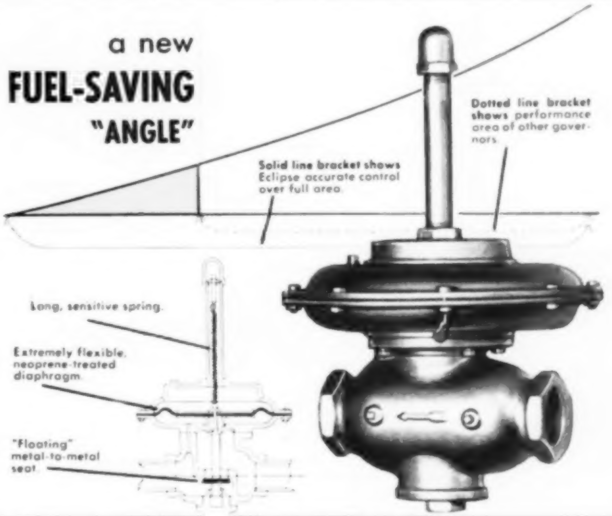
290. Gas/Air Regulator

Bulletin M-400 gives technical data and specifications of zero governor. *Eclipse Fuel Engineering Co.*

291. Gas Cutting Machine

Airco No. 30 Radiagraph, portable gas cutting machine, is described and illustrated in 8-page folder. *Air Reduction Sales Co.*

a new
FUEL-SAVING
"ANGLE"



Yellow "angle" area shows "golden opportunity" for dollar-saving with Eclipse Governor.

McKEE ECLIPSE
ZERO GAS GOVERNOR
Maintains Economical Air-Ratio over the Entire Operating Range of the Burner.

t will pay you to check your present zero governor, to see if it provides the proper air-gas ratio and precision control, all the way down to the minimum gas flow, to make sure you are not sacrificing important ranges of operation.

The McKee ECLIPSE Zero Governor is a low-pressure, proportional mixer, specially designed with extremely sensitive springs and diaphragms (illustrated above) in order to accurately control even a very small amount of gas flow.

This precision control at *all* operating ranges means a dollar-and-cents saving for users of McKee ECLIPSE Zero Governors. Gas-burning installations, whether single or multiple burner, are usually engineered to operate at specific temperatures, and often at a minimum firing rate. Consequently it is highly important to have a governor, such as the McKee ECLIPSE, that is highly sensitive to even the slightest gas flow. With all their precision construction, these governors are sufficiently rugged to meet drastic requirements of everyday combustion equipment operation.

Write for descriptive bulletin M-400, which includes technical data and specifications. Or see Sweets Product Designers' or Process Industries Catalogs.

Representatives in All Principal Cities

Eclipse Fuel Engineering Company
1127 Buchanan St., Rockford, Ill.
McKee Eclipse

NOW IN OUR MODERN, NEW PLANT, WITH MOST COMPLETE LINE OF GAS-FIRING EQUIPMENT

Let's take a CLOSER LOOK at STRAIGHT-CHROMIUM Stainless Steel Tubing

Present restrictions on nickel have cut production of austenitic stainless steel tubing far below demand. If this critical shortage of nickel-bearing stainless tubing is compelling you to find other suitable grades, you should take a closer look at the straight-chromium analyses.

Readily available in quantity from B&W are pipe and tubes of the four non-nickel-bearing types listed at the right with typical uses. These ferritic and martensitic steels are magnetic at ordinary temperatures after all conditions of heat treatment, have relatively high oxidation resistance at elevated temperatures, and resist attack by many corrosive media. With certain modifications in procedures, they can be satisfactorily fabricated by all methods applicable to austenitic grades.

For both pressure and mechanical applications, tubes of straight-chromium stainless analyses are worthy alternates for hard-to-get nickel-bearing stainless types. Would you like a copy of TDC-140 containing technical data on these easy-to-get grades of stainless tubes? Ask Mr. Tubes—your B&W Tube Representative—about their suitability for your applications.

APPLICATIONS

B&W Croloy 12 A1 (Type 405, Seamless)—Non-hardening—does not undergo appreciable transformation; therefore no sudden volume change occurs during heating—corrosion and oxidation resistant. Typical uses: Conveyor lines in oil refining and chemical processing, heat exchanger tubing, boiler tubing in mercury heat cycle, catalytic oil cracking processes where fins have been welded to tubes.

B&W Croloy 12 (Type 410, Seamless and Welded)—Hardenable—moderate corrosion and heat resistance. Typical uses: Machinery in the chemical and food processing and packaging fields.

B&W Croloy 18 (Type 430, Seamless and Welded)—Sufficient ductility for forming simple parts—good corrosion and oxidation resistance—can be polished or buffed to pleasing finish. Typical uses: Conveyor lines in chemical processing field; condensers and piping in production, transportation, and storage of nitric acid and in nitrating operations involving mixed acids; furnace parts; retorts; ornamental structures.

B&W Croloy 27 (Type 446, Seamless)—Corrosion resistant—excellent heat resisting qualities. Typical uses: Furnace parts, heat interchangers, kilns, pyrometer protection tubes, soot blower elements, dehydrogenation equipment in chemical and oil refining fields. Also well suited for glass sealing applications.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION

General Offices & Plants

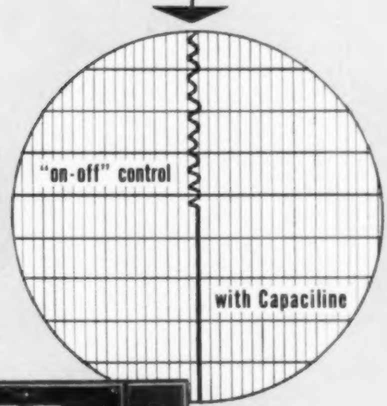
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

Sales Offices: Beaver Falls, Pa. • Boston 16, Mass. • Chicago 3, Ill. Cleveland 14, Ohio • Denver 1, Colo. • Detroit 26, Mich. • Houston 2, Texas • Los Angeles 17, Cal. • New York 16, N. Y. • Philadelphia 2, Pa. • St. Louis 1, Mo. • San Francisco 3, Cal. • Syracuse 2, N. Y. Toronto, Ontario • Tulsa 3, Okla.

B&W SEAMLESS and WELDED TUBES

TA-1651S

wheelco instrumentality



STRAIGHT LINE CONTROL

wheelco capacitrol-capaciline

Get Model 252P Capacitrol—and get *improved instrumentation!* Wheelco Capacitrols are now available with Capaciline—giving you *built-in straight-line control!* This simple and economical electronic indicating controller may be applied to obtain results equal to most high-cost proportioning systems. Whatever your temperature problem—whether it's heat treating, melting, brazing, molding, forming, etc.—it will pay you to buy the Wheelco Capacitrol-Capaciline. It is available for use at temperatures up to 3600° F.

The Capaciline Model 660 *accelerator* may be purchased separately as a self-contained unit for use with any Wheelco Capacitrol or any other two position pyrometer controller.

Write today for Bulletins PC-1 and CL-1—ask too, for the 42 page Thermocouple Data Book and Catalog—it's filled with complete information, facts and charts covering all types of control accessories. Wheelco Instruments Company, 835 W. Harrison Street, Chicago 7, Ill.

wheelco *electronic controls*

Manufacturers of Capacilog strip chart recorders, Flame-otrol combustion safeguards

292. Gas Cutting Machine
New catalog available on Airco No. 50 Travograph gas cutting machine, equipped with three distinctly different tracing devices—manual, magnetic, or full-automatic Electronic Bloodhound to cut most intricate shapes from only an outline drawing. *Air Reduction Sales Co.*

293. Grinders
Catalog No. 75 describes bench and floor-type wheel grinders, polishing lathes and backstands of various sizes and capacities. *Hammond Machinery Builders, Inc.*

294. Hardness Tester
Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. Also included is bulletin DH-7, outlining experiences in various fields. *Wilson Mechanical Instrument Co.*

295. Heating Elements
Bulletin H gives detailed information on AT-type nonmetallic electric heating elements, including tables for a wide variety of sizes available. *Globar Div., Carborundum Co.*

296. Heat Treating
4-page folder lists hardening and annealing services available for manufacturers of products and users of equipment made of stainless steel. *The Drever Co.*

297. Heat Treating
Booklet describes complete diversified facilities for steel, aluminum and magnesium heat treating. *Pearson Industrial Steel Treating Co.*

298. Heat Treating
Data Sheet lists complete line of heat treat services available at plant. *Vincent Steel Process Co.*

299. Heat Treating
40-page booklet on facilities for tool heat treat, bright hardening of stainless, case hardening, machine quenching, cleaning, straightening and inspection. *Commercial Steel Treating Corp.*

300. Heat Treating
Ipsenlab periodic sheets show case histories on bright hardening, annealing and carburizing. *Ipsen Industries, Inc.*

301. Heat Treating
Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. *Sunbeam Industrial Furnace Division.*

302. Heat Treating Fixtures
Information on complete line of standard carburizing carriers that will handle odd-shaped parts of every type thru carburizing and quenching to finishing. *Pressed Steel Co.*

303. Heat Treating Furnaces
Illustrated literature describes newest developments in gas and electric heat treating furnaces. *Westinghouse Electric Corp.*

304. Heat Treating Furnaces
Performance charts on fuel fired or electric heat treating furnaces for hardening, tempering, annealing, normalizing, stress relieving, and aluminum treating. Furnace design incorporates both convection and radiant methods of heating. *Standard American Engineering Co.*

305. High Temperature Alloy
Preliminary bulletin describes "Incoloy", new nickel-chromium alloy for high temperature and corrosive environments. *International Nickel Co., Inc.*

306. Immersion Heating
Bulletin IE-11 gives complete details on how new immersion pots save time and money in melting soft metals. High thermal efficiency for both large and small units provides rapid heat recovery in one-third the time. *C. M. Kemp Mfg. Co.*

307. Impregnating Castings
Literature on new impregnating equipment for elimination of porosity in ferrous and nonferrous castings. *Metallizing Co. of America.*

308. Induction Heating
Illustrated bulletin on low-frequency (60 cycle) induction heating furnace. Fully descriptive with applications. *Magnethermic Corp.*

309. Induction Heating
"Induction Heating . . . the machine tool that makes tall stories come true" presents case histories of how induction heating has increased production, reduced space and cut production costs. *Westinghouse Electric Corp.*

310. Induction Heating
General data folder informs concerning megacycle tube-type machines for soldering, brazing, bombarding, annealing and hardening. Fully illustrated. *Sherman Industrial Electronics Co.*

311. Inspection Light
Literature available on instrument that spotlights the work and magnifies it at the same time. For inspection. *E. W. Pike & Co.*

312. Instruments
Folder No. 4A gives advantages of direct-reading analytical balance which will weigh samples up to 200 grams in weight. *Fisher Scientific Co.*

313. Instruments
"Tomorrow Is Today" is a new brochure telling of the many contributions of instruments to industrial processing. *Minneapolis-Honeywell Regulator Co.*

314. Instruments
Capacitrols and capaclines are described in bulletins PC-1 and CL-1. *Wheelco Instruments Co.*

315. Laboratory Equipment
Data available on complete line of spectrographic equipment. *National Spectrographic Laboratories, Inc.*

316. Laboratory Furnaces
Series of data sheets give full information on complete line of laboratory furnaces for numerous metallurgical operations. *Boder Scientific Co.*

317. Laboratory Grinding
Bulletin describes equipment for fine grinding of specimens with emery papers or wet-type silicon carbide papers or cloths by both hand and motor powered grinders. *Buehler Ltd.*

318. Lapping Machines
16-page booklet offers charts, illustrations and data on machines for automatic precision lapping of all materials in any production quantity. *Crane Packing Co.*

319. Lubricant, Metal Forming
Well-illustrated brochure showing eight difficult parts stamped, blanked or drawn, using wax lubricants. Metals include aluminum, deep drawing steel, 430 and 446 stainless, and electrical sheet. *S. C. Johnson & Son, Inc.*

320. Lubrication, Metalworking
The uses of colloidal graphite for hot metalworking operations (deep piercing, casting, forging, stretch-forming and wire drawing operations) are explained in bulletin No. 426-10B. *Acheson Colloids Corp.*

321. Machining Copper Alloys
32-page booklet suggests cutting speeds, feeds, tool rakes and clearances for more than 40 copper alloys. *American Brass Co.*

322. Metal Finishing
New check list available on sixty products and processes for metal finishing, including a new acid addition agent, a cleaning and pickling agent combined, a new complete inhibitor and a new rust-preventive compound. *Enthone, Inc.*

323. Metal Forming Machine
Six-page bulletin on machine for bending, folding and shaping of sheet and strip. *Kilham Engineering Sales Co.*

324. Metal Treating Ammonia
Booklets available on "Applications of Dissociated Ammonia", "Ammonia Installations for Metal Treating", "The Nitriding Process", and "Carbonitriding". *Armour & Co.*

325. Metal Working Lubricant
Data sheet on solid waxes in stick form for use as lubricant in sawing, threading, drilling, tapping, spinning and grinding. *S. C. Johnson & Son, Inc.*

326. Nondestructive Inspection
Series of bulletins give data on both ultrasonic and magnetic nondestructive testing instruments. Illustrated. *J. W. Dice Co.*

327. Nondestructive Inspect
Data available on electronic inspection
ment, demagnetizers and comparators for so
Magnetic Analysis Corp.

328. Nonferrous Castings
8 pages of tabular data on standard
bronze, nickel silver, aluminum bronze, mang
bronze, aluminum and zinc casting alloys,
December issue of Lavingot. *R. Lavin & Son*

329. Pickling Compound
Folder on "Rodine" tells of its use in pi
solutions to prevent embrittlement of steel.
ican Chemical Paint Co.

330. Pipe and Tubing
Stock List, No. 109, lists seamless and w
alloy and stainless steel tubing and pipe s
Babcock & Wilcox Co.

331. Plating Barrels
4-page folder illustrates and describes
ment designed to handle any barrel plating
lem quickly and easily with a unique c
arrangement for maximum current distrib
Daniels Plating Barrel & Supply Co.

332. Plating Racks
8-page, illustrated booklet offers data
plating rack designed to make the spline
or body of the plating rack a permanent
National Rack Co., Inc.

333. Polishing Materials
20-page booklet includes samples of
aluminum oxide and silicon carbide paper
12 polishing cloths. Trade names, particle
etc. *Buehler, Ltd.*

334. Precision Castings
Illustrated folder shows samples of inve
castings produced of various ferrous and
ferrous alloys. Advantages of these ca
Engineered Precision Casting Co.

335. Presses, Bending
Steelweld presses for bending, forming,
ing, drawing and multipunching operatio
described in catalog No. 2010. *Cleveland C
Engineering Co.*

336. Product Information
Entirely new "Product Information Fil
forms, comprehensively, on time-tested ind
germicides and fungicides. Tells how to
effective, economical microbial control to
The Dow Chemical Co.

337. Pyrometer
Specification Sheet No. 83 gives infor
about new miniature Radiamatic, a ra
detecting temperature measuring device d
for flame hardening and induction heatin
chines. *Minneapolis-Honeywell Regulator C*

338. Pyrometer
Catalog No. 165 describes improved Pyro
pyrometer. Eight instruments in one, it
surface and sub-surface temperature me
jobs. *Pyrometer Instrument Co.*

339. Pyrometer
New circular gives complete informat
Xactemp pyrometers. New Type LT-8
all accessories are illustrated and de
Xactline straight-line temperature control
with any standard pyrometer controller
scribed in a companion folder. *Claud S. Go*

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HEAT TREATING FURNACES

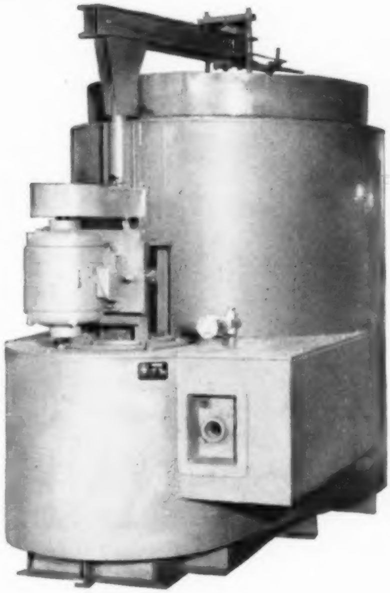
FOR UTILITY AND PRODUCTION — HARDENING, TEMPERING, ANNEALING, NORMALIZING, STRESS RELIEVING, ALUMINUM TREATING, ETC.

★ **TEMPER 2,000,000 lbs.** *More Work* A Year Using Less Floor Space Than Any Convection or Other Draw Furnace Built.

★ Uses 25% less gas.

★ Let Your New Furnace Pay For Itself In Four Months *Through Increased Production.*

★ Improve Surface Condition — Avoid Excess Scale and "Burned" Work.



Claims apply to gas heating of work loading 75 pounds a cubic foot. Denser loading improves RADIVECTION Advantage.

Write for Verified Performance Charts . . .

. . . and Names of RADIVECTION Users

STANDARD AMERICAN ENGINEERING Co.

7851 W. 43rd Street, Lyons, Illinois

340. Pyrometers
Data sheets available on high resistance indicating pyrometers. Also pyrometer controls and resistance thermometers. *Taco West Corp.*

341. Pyrometer Supplies
Catalog 100-4 furnishes useful technical data on the application and use of thermocouple pyrometric supplies. *Minneapolis-Honeywell Regulator Co.*

342. Quench Agitation
Information on mixers and agitators, including units applicable to industrial quenching equipment. *Mixing Equipment Co., Inc.*

343. Radioactive Materials
The basic fields in which radioactive materials may be used in the solution of metalworking problems are outlined in recent publication. *Tracerlab, Inc.*

344. Radioisotopes
Booklet on use of isotopes as tracers in industrial research and testing. *United States Testing Co., Inc.*

345. Recorder
Detailed bulletin 407 and data sheet AED 340-7 contain facts about dew point systems available for recording or recording-controlling. Wide range of working temperatures. *Foxboro Co.*

346. Refractories
New 20-page booklet gives technical information of a basic nature on super refractories. Text material is supplemented with charts, tables, illustrations and application data. *Carborundum Co., Refractories Div.*

347. Refractories
Revised bulletin entitled "Lumnite Refractory Concrete" discusses latest available information on refractories and heat-resistant concrete. *Lumnite Div., Universal Atlas Cement Co.*

348. Refractory Mixes
Well-illustrated 16-page bulletin No. 315 provides important data on properties and applications of Sillimanite super-refractory ramming mixes and patches. *Chas. Taylor Sons Co.*

349. Rhodium Plating
Directions for rhodium plating, with particular reference to its use as replacement for the usual plating metals. *Baker & Co., Inc.*

350. Roller Dies
Data sheet gives information on roller dies for forming tubes, pipe and cold rolled shapes. For all roll forming machines. *American Roller Die Corp.*

351. Selective Carburizer
Bulletin on "No-Carb" for selective carburizing and prevention of decarburizing on high alloy steels during heating for hardening. *Park Chemical Co.*

352. Shotblasting
"A Primer on the Use of Shot and Grit" is the title of an attractive 16-page booklet on problems of blast cleaning operations. *Hickman, Williams & Co.*

353. Silver Brazing
Illustrated booklet treats all aspects of brazing applications and problems. *American Platinum Works.*

354. Soldering Equipment
8-page brochure on soldering and brazing equipment describes new Mogul soldering gun and shows its applications to production-line soldering and brazing. *Metallizing Co. of America.*

355. Spectrophotometer
Bulletin B-211 illustrates junior-size spectrophotometer for identifying and measuring solution constituents in analytical or production laboratories. *Harshaw Scientific Div.*

356. Spray Booths
Bulletin has 15 pages of photos, diagrams and information on hydro-whirl spray booths in all sizes and arrangements for manual or automatic spraying. *Peters-Dalton, Inc.*

357. Spring Steel
Handbook describes various spring steels and gives tolerance tables, heat treatment and physical property tables and fabrication data. *A. R. Purdy Co., Inc.*

358. Stainless Spring Wire
Spring properties, applications, cost comparison among various spring metals as function of wire diameter. *Alloy Metal Wire Co., Inc.*

359. Stainless Steel
120-page reference book, cloth bound, on properties, selection, treatment, and fabrication of stainless steels. Wrought forms and castings; high and low temperature properties. Many tables. *Allegheny Ludlum Steel Corp.*

360. Stainless Steel Castings
28-page full-color industrial fantasy, "Alloys in Cooperland", captures the spirit of Lewis Carroll in describing how stainless steel castings are made. *The Cooper Alloy Foundry Co.*

361. Steel, Aircraft
New printing "Aircraft Steels" booklet which includes revised military specs to August 1951. Also sizes and analyses of aircraft steels carried in stock. *Joseph T. Ryerson & Son, Inc.*

362. Steel Bars
New wall chart of 275 different grades of standard, special and alloy steel bars shows chemical analyses and other data. *LaSalle Steel Co.*

363. Stress Analysis
Revised edition of "Photoelastic Stress Analysis" shows the engineer why this method is effective for solving problems of stress distribution. *Eastman Kodak Co.*

364. Subzero Freezer
4-page folder on portable freezer, 110-volt a.c. operating to —180° F., for shrink fitting, hardening, stabilizing, and testing. *Webber Appliance Co., Inc.*

365. Subzero Treatment
Advantages of low-temperature metal treatment are described in a new 8-page folder. Processes covered are for stabilization, increasing tool life and shrink-fit assembly. *Deepfreeze Distributing Corp.*

366. Surface Hardening
6-page booklet gives information concerning non-poisonous, non-explosive and non-inflammable surface hardening compounds. Illustrations and engineering charts. *Kasenit Co.*

367. Temperature Control
New catalog of improved pyrometer supplies gives data on thermocouples, protection tubes, thermocouple and lead wire, insulations and terminal heads. *Arklay S. Richards Co., Inc.*

368. Temperature Control
New 52-page catalog covers design, operating characteristics and installation of each of 10 types of thermostatic devices. *Fenwal, Inc.*

369. Testing
Literature available on tensile and Brinell testing machines. *Detroit Testing Machine Co.*

370. Testing Machine
32-page catalog lists all Riehle hydraulic universal testing machines. Illustrations, specifications, advantages, operating details. *American Machine and Metals, Inc.*

371. Thermocouples
Catalog H gives complete description of thermocouples designed for special and unusual requirements. *Thermo Electric Co.*

372. Tool Steels
198-page cloth bound reference book on tool steels. Types, properties, applications, selection, working, heat treatment. Bar, rod, forgings, cemented carbides, cast-to-shape tool steel. *Allegheny Ludlum Steel Corp.*

373. Tool Steels
Circle "M", Star-Mo and Van Chip are three high speed steels described in folders covering mechanical and heat treating data and applications. *Firth Sterling Steel & Carbide Corp.*

374. Tool Steels
Information on Warplis products, stock size and price folders will be sent on request, along with name of nearest distributor. *Pittsburgh Tool Steel Wire Co.*

375. Tool Steels
86-page pocket-size handbook on application and heat treatment of 27 grades of tool and die steels. *Ziv Steel & Wire Co.*

376. Tool Steels
Full information on uses, compositions and heat treatment of carbon and carbon-vanadium tool steels. *Vanadium-Alloys Steel Co.*

377. Tool Steel Color Guide
Color guide to estimate the temperatures of heated steels has heat colors on one side and temper colors on the other side. *Bethlehem Steel Co.*

378. Tool Steel Selector
Handy, clearly printed, easy-to-use tool steel selector will be furnished on request. *Crucible Steel Co. of America.*

379. Tubing
42-page "Handbook on Cold Drawn Butt Welded Mechanical Steel Tubing" discusses processing, utility and types. Illustrated. Many useful tables. *Pittsburgh Tube Co.*

380. Tubing Failures
Factors affecting tube life in high-pressure, high-temperature applications are presented in 40-page booklet which is the result of a great number of investigations of failures. *Babcock & Wilcox Tube Co.*

381. Vibration Testing
Six-page folder of specifications and photos of eight models of vibration fatigue testing equipment. *All American Tool & Mfg. Co.*

382. Wax Lubricant
Free sample and complete information on use of wax lubricant in difficult drawing and stamping operations. *S. C. Johnson & Son, Inc.*

383. Welding Electrodes
Wall chart of bronze welding electrodes gives AWS-ASTM designations, applications, properties and other data. *Ampco Metal, Inc.*

384. Welding Equipment
Cadweld process and complete list of arc-welding accessories are described in catalog. *Erico Products, Inc.*

385. Welding Equipment
Welder's crayons for permanent markings on metal surfaces are described in folder. *Wm. Korn, Inc.*

386. Welding Rods
Guide to use and selection of electric arc rods and gas rods and fluxes. *Permalatem Welding Alloys, Inc.*

387. Welding Stainless
1-page reprint on heavy stock on welding of stainless alloys by company chief metallurgist. *Cooper Alloy Foundry Co.*

388. Wire, Nonferrous
4-page folder contains wire gage and footage chart and information on beryllium copper, phosphor bronze, nickel silver, brass and aluminum wire. *Little Falls Alloys, Inc.*

389. X-Ray Diffraction
Bulletin 304 describes the Hilger X-ray diffraction unit for determining internal strain or distortion, types of alloy formation, grain sizes and effect of heat treatment to establish correct annealing technique. *Jarrell-Ash Co.*

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METAL PROGRESS, 7301 Euclid Avenue, Cleveland 3, Ohio

February, 1952

213	240	267	294	321	348	375
214	241	268	295	322	349	376
215	242	269	296	323	350	377
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238	265	292	319	346	373	
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Company ______________________

Products Manufactured ______________________

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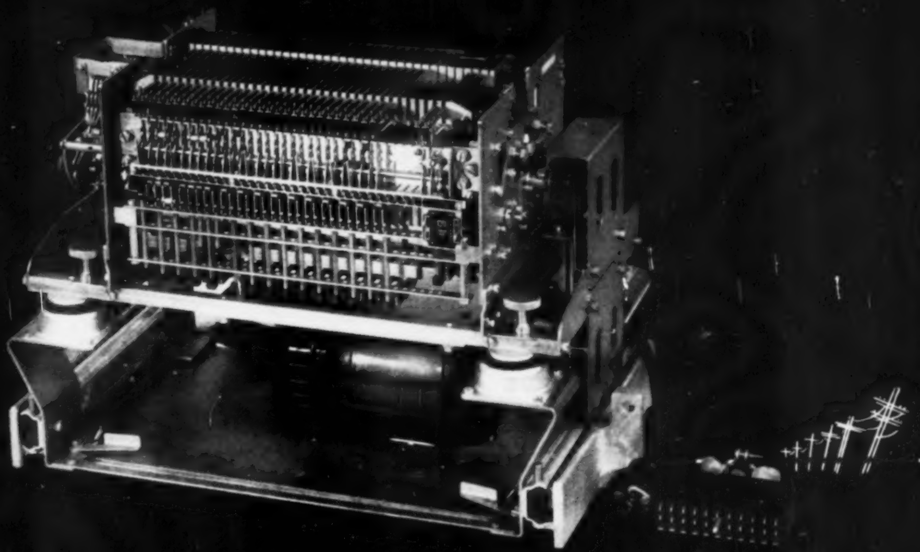
Postcard must be mailed prior to May 1, 1952—
Students should write direct to manufacturers.

Readin', Recognizin' and Respondin'...



SHARON* SPECIAL ALLOY USED BY TELETYPE† IN AMAZING NEW SEQUENTIAL CONTROL . . .

Teletype Corporation recently produced a compact machine that actually knows its Three R's. In this case the R's are Reading, Recognizing and Responding. It will Read every signal coming over a Teletype† line, Recognize predetermined sequences of the signal and Respond automatically.

The design of this machine calls for analyses of alloy steels that must be worked to exceptionally close tolerances. Teletype† found many of the alloys required in exactly the right analyses and uniformity simply by contacting their Sharon representative.

If you have a job that calls for a special alloy, coated or stainless steel strip, the name Sharon belongs high on your supplier list.

† TM of Teletype Corporation

*Specialists in STAINLESS, ALLOY, COLD ROLLED and COATED Strip Steels.

SHARON STEEL CORPORATION

Sharon, Pennsylvania

DISTRICT SALES OFFICES: CHICAGO, ILL., CINCINNATI, O., CLEVELAND, O., DAYTON, O., DETROIT, MICH., INDIANAPOLIS, IND., MILWAUKEE, WIS., NEW YORK, N. Y., PHILADELPHIA, PENNA., ROCHESTER, N. Y., LOS ANGELES, CALIF., SAN FRANCISCO, CALIF., MONTREAL, QUE., TORONTO, ONT.

For information on Titanium Developments contact Mallory-Sharon Titanium Corp., Indianapolis 6

SHARONSTEEL

MAGNESIUM

and the

problem of

DESIGN

in your product

IN PRODUCT DESIGN, magnesium offers the outstanding advantage of a high strength/weight ratio. This single factor has many interesting applications.

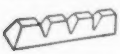
Suppose your product . . . up for re-design . . . has met a sales penalty of excessive weight. In re-designing, you have a choice of several metals. But only one . . . magnesium . . . can offer you the best combination of light weight, strength and rigidity.

Perhaps your product requires additional parts to increase its efficiency, its saleability. Yet the addition of those parts may mean undesirable weight. By re-designing with magnesium, many manufacturers have found it possible to add improvements without increasing weight.

Another type of design advantage is often utilized where no weight saving is necessary. Because of its strength/weight ratio, magnesium makes possible greatly simplified construction with resultant lower costs. Recently a large, complex structure was re-designed in magnesium with a reduction of 69% in the number of pieces required and reducing the number of fasteners 62%.

Magnesium offers real flexibility in design with a variety of alloys possessing characteristics of strength, toughness, machinability and corrosion resistance. Fabricated magnesium is produced in all common forms: castings, forgings, extrusion, sheet and plate; and can be economically worked by all standard shop practices.

This Little "Pig" Was Drafted . . .

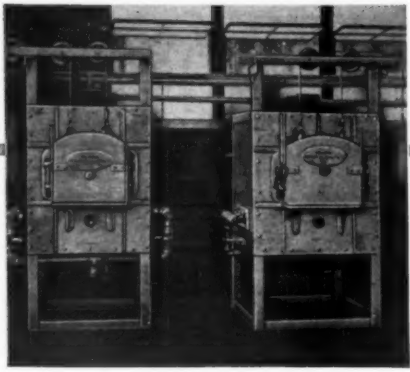


Today, magnesium like many other metals, is a tremendously important part of our defense effort, particularly where light weight is a specification in design. As a result, the supply for commercial uses is often limited. But tomorrow, magnesium promises new horizons in the field of metal supply. *The seas, at our own shores, can provide 100 million tons per year for a million years without significantly reducing the supply.*

THE DOW CHEMICAL COMPANY

Magnesium Department • Midland, Michigan

New York • Boston • Philadelphia • Atlanta • Cleveland • Detroit • Chicago
St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada



BELLEVUE INDUSTRIAL FURNACE CO.

These atmosphere controlled toolroom furnaces are equipped with hearths made of CARBOFRAX silicon carbide refractory. CARBOFRAX hearths conduct heat very rapidly and assure even temperature conditions throughout the working chambers, as well as quick comeback after charging.

Super Refractories by

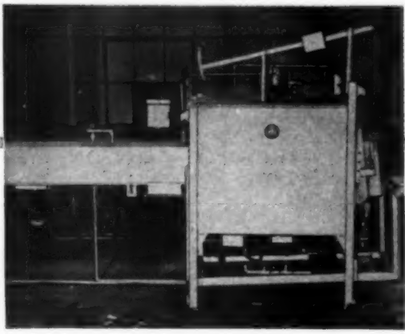
CARBORUNDUM

Trade Mark

make good furnaces better

HOSKINS MANUFACTURING CO.

This copper brazing furnace is electrically heated and uses a hydrogen atmosphere. It has a CARBOFRAX hearth that is able to withstand the temperatures encountered and resists attack by molten copper particles. It is not only a tough and durable hearth, but it's also unaffected by the gas, an important factor in any atmosphere furnace.



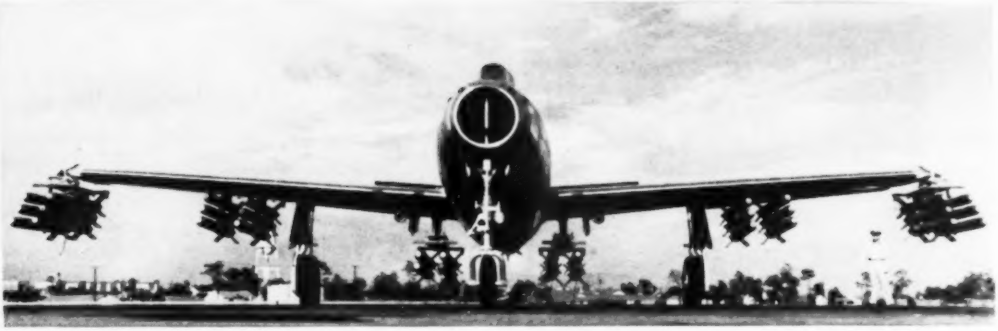
WESTINGHOUSE ELECTRIC CORP.

This box type pusher furnace is normally used for protective atmosphere brazing, but can also be used for annealing, sintering or hardening. Rated maximum operating temperature is 2100 F. Trays travel through on a CARBOFRAX hearth that is always hard and smooth—never prone to warp or erode.

Dept. C-22, Refractories Division

The Carborundum Company, Perth Amboy, N. J.

"Carborundum" and "Carbofrax" are registered trademarks which indicate manufacture by The Carborundum Company.



Free-Machining ENDURO Flies with the Thunderjets

Parker AN fittings, manufactured of Type 316 ENDURO Stainless Steel by Parker Appliance Company, Cleveland, Ohio, fly with Republic Thunderjets and with many other aircraft.

Machined fittings for aircraft hydraulic control systems must, above all, be strong and tough. They must contain pressures as high as 3000 psi and possess high safety margins. They must fight off all attacks of corrosion and fatigue. They must resist the effects of sudden changes in temperature and atmospheric pressure.

The material to provide all these qualities, yet be economical to forge and to machine? It's ENDURO Stainless Steel, available in free-machining grades, either hot rolled or cold drawn bars.

ENDURO responds uniformly to forging—and, as these fittings indicate, is readily machinable.

ENDURO Cold Finished Bars are processed by Republic's Union Drawn Steel Division to provide close tolerances, accuracy of section, uniform soundness and fine surface finish. Two grades are approximately 90% as machinable as Bessemer screw stock.

To help you use ENDURO to cut costs and speed production of stainless steel bar parts, Republic offers you prompt, competent metallurgical assistance. Just write:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

Republic ENDURO®
FREE-MACHINING
STAINLESS STEEL
REPUBLIC STEEL

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

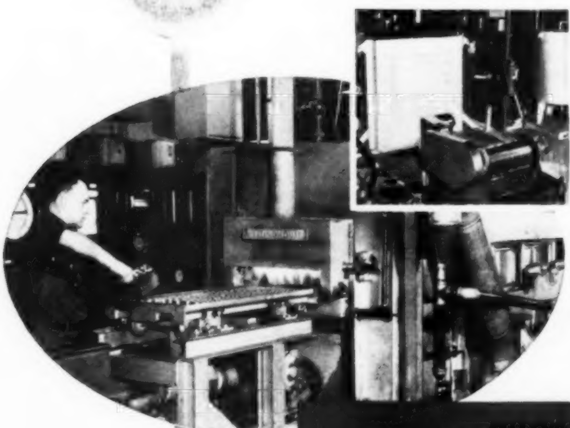
"So satisfactory we've ordered another"

"Our Westinghouse Furnace has proved so satisfactory that we've ordered another one", says Marlin-Rockwell Corporation, Plainville, Connecticut—manufacturer of ball bearings.

"The furnace has resulted in at least 50% improvement in the production-per-man-hour ratio over the system we previously used. Controlled feeding of small bearing rings and retainers permits gradual heating. This, along with controlled temperature of the quenching bath, practically eliminates distortion.

"Proper atmospheric control provides the right bright-hardening, entirely eliminating sandblasting. Our bearings have a better finish, and are a better product."

Gas-fired or electric, there's a Westinghouse Furnace to meet every heat-treating need. Westinghouse Electric Corporation, Industrial Heating Works, Meadville, Pennsylvania. J-10368



IF YOUR PRODUCT CALLS FOR HEAT-TREATING . . . IT CALLS FOR A WESTINGHOUSE FURNACE . . . GAS OR ELECTRIC

YOU CAN BE SURE... IF IT'S Westinghouse

HEAT-TREATING FURNACES

GO "AUTOMATIC" ... save money ...

in controlling bath temperatures for PLATING • PICKLING • DEGREASING

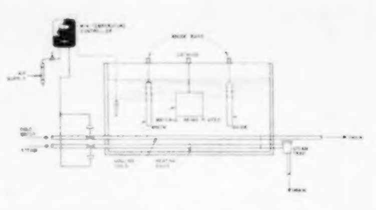
It takes only a few degrees variation from correct bath temperature to make the difference between fine finish with cost *savings*, and poor finish with costly *wastes*. That is why it is real economy to replace undependable manual control of finishing temperatures with *automatic* Foxboro Control. Here are typical advantages:

Plating — Temperatures a few degrees too high or low can produce dull, lustreless, off-color, brittle, or streaked plating. The Foxboro M-41 Controller automatically holds temperature so close to optimum that faults due to temperature variations are entirely eliminated.

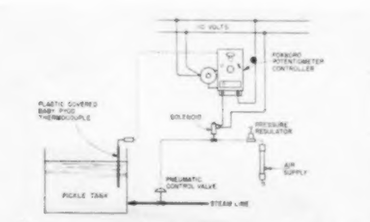
Pickling — Foxboro Automatic Control of strong acid pickling bath temperatures conserves both acid and steam by eliminating overheating and boiling. It increases production and quality from the unit by maintaining the optimum high temperature.

Degreasing — Automatic Foxboro Control of degreaser temperature insures proper vapor level, prevents loss of vapors over top edge of the tank. This also reduces the hazard to health of operators due to boil-over.

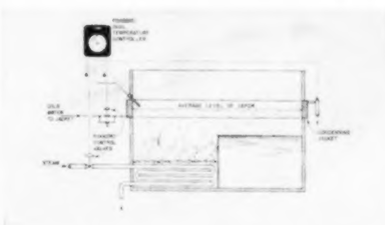
Whatever your finishing bath may be, maintaining proper temperature is a problem which has only two solutions: automatic temperature control; or constant, manual attention by the plating room operators. Foxboro Automatic Temperature Control does it easier, less expensively, and more dependably! Write for technical recommendations on your operations. The Foxboro Company, 522 Neponset Ave., Foxboro, Mass., U. S. A.



Chromium Plating bath temperature control



Strong acid pickling bath temperature control



Solvent degreaser temperature control

FOXBORO
REG. U. S. PAT. OFF.

Instruments that improve product uniformity

ALLOY STEEL UNNECESSARY!

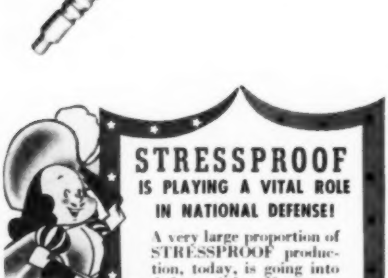
THREE OPERATIONS ELIMINATED

- QUENCHING
- TEMPERING
- STRAIGHTENING

Ground and Polished STRESSPROOF has been used for lead and feed screws by Kearney & Trecker since 1939. If STRESSPROOF were not available, they would need a .50% carbon-alloy steel to obtain the required strength and wear-resistant properties. The substitution of alloy would require quenching and tempering, and straightening—operations not necessary with Ground and Polished STRESSPROOF. The cost of the part would be more than doubled.

For precision work, lead and feed screws for machine tools must maintain their accuracy through years of operation. Ground and polished STRESSPROOF cuts cost for these exacting parts because it provides *five* qualities in the bar—(1) *high strength*, double that of ordinary cold-finished shafting; (2) *machinability*, fully 50% better than heat-treated alloys of the same hardness; (3) *high resistance to wear*, replacing many heat-treated or carburized alloys; (4) *minimum warpage*, obtained by special processing; and (5) *accurate, finely ground surface*.

It is significant that the only suitable substitute for STRESSPROOF is an alloy steel requiring many additional expensive production operations.



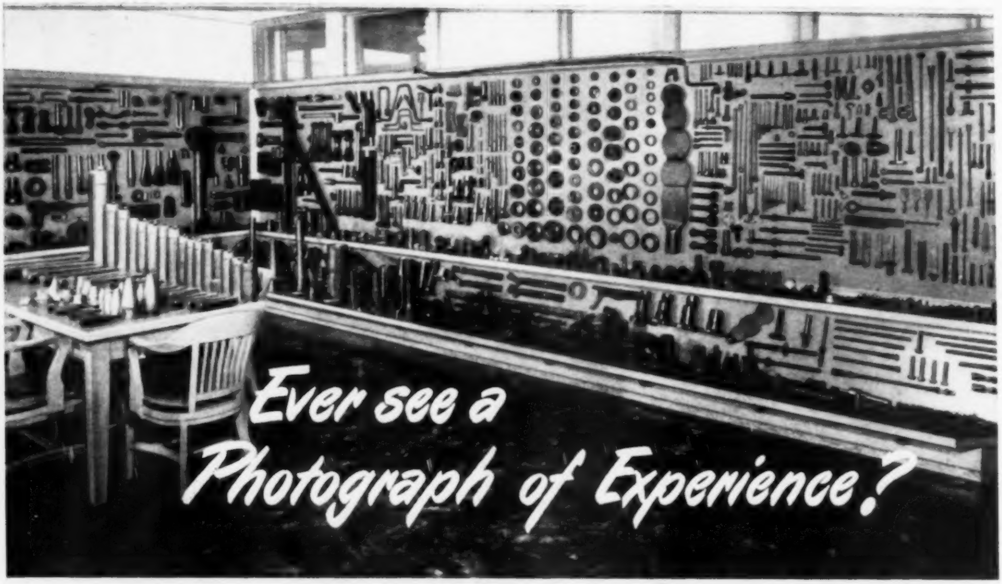
STRESSPROOF IS PLAYING A VITAL ROLE IN NATIONAL DEFENSE!

A very large proportion of STRESSPROOF production, today, is going into defense jobs. However, sample bars are available for testing purposes.

La Salle STEEL CO.

1424 150th Street, Hammond, Indiana

Manufacturers of the Most Complete Line of Cold-Finished and Ground and Polished Bars in America



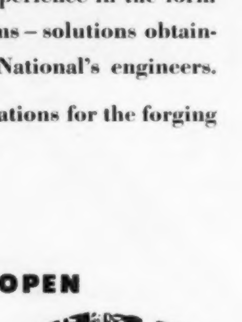
Experience is generally thought of as being something intangible. But this photograph of our display room portrays experience in the form of tangible solutions to countless forging problems – solutions obtained through cooperation between industry and National's engineers.

Our leadership in pioneering methods and applications for the forging industry establishes our ability to help you best.

THIS DOOR IS ALWAYS OPEN

Our entire organization is always at your service. Send us prints or a sample of the part you wish to forge—hot or cold, large or small. Better yet, pay us a visit.

No obligation, of course.



NATIONAL
MACHINERY COMPANY
TIFFIN, OHIO—SINCE 1874

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES • MAXIPRESSES • REDUCEROLLS • COLD HEADERS • BOLTMAKERS • NUT FORMERS • TAPPERS • NAILMAKERS

Hartford   Detroit   Chicago

Check the advantages of melting and remelting quality steel with TOCCO Induction Heating

Several TOCCO melting furnaces may be operated from one TOCCO high-frequency power source.

- ✓ Extremely Rapid Melting
- ✓ High Efficiency on Intermittent Operation
- ✓ Good Mixing because of Natural Agitation
- ✓ Extremely Low Alloy Loss
- ✓ High Reproducibility of Results
- ✓ No Carbon Pick-up
- ✓ No Contamination when Composition of Charges is Changed
- ✓ Minimum Space Requirements
- ✓ No Special Installation Charge
- ✓ Simple, Safe Operation
- ✓ Clean, Comfortable Working Conditions

If any of these advantages suggest economies in your operations write us for full details—no obligation, of course.

Some Users of TOCCO High-Frequency Melting Furnaces

American Electro Metal Corp.
Haynes Stellite Company
E. I. Dupont de Nemours & Co.
Union Carbide and Carbon Corporation
Allis-Chalmers Mfg. Co.
Watertown Arsenal
Wright Aeronautical Corporation
Watervliet Arsenal
Arwood Precision Casting Co.
Various Atomic Energy Plants and Laboratories

THE OHIO CRANKSHAFT COMPANY
CLEVELAND 1, OHIO

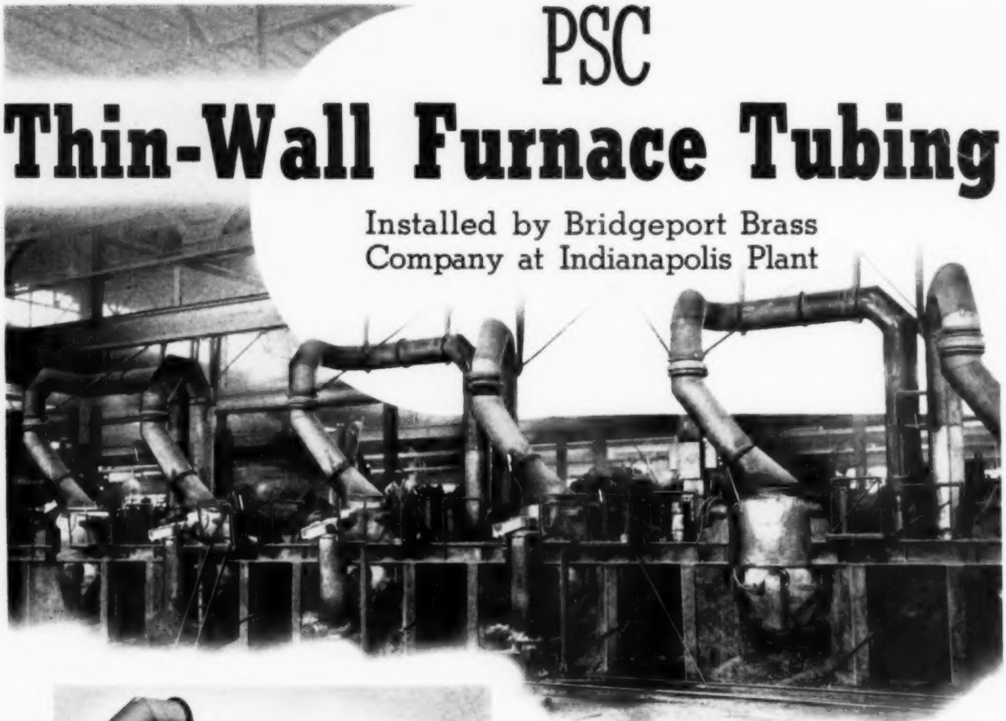
JUST PUSH A BUTTON

TOCCO

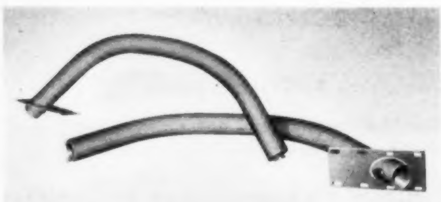
Hardening • Brazing
Annealing • Soldering
Forging • Melting

PSC
Thin-Wall Furnace Tubing

Installed by Bridgeport Brass
Company at Indianapolis Plant



For External or Internal Furnace Applications, in Most *Complicated* Designs



We precision assemble the most complicated designs of radiant furnace tubes. Send blue prints or write as to your needs.

These vent stacks loom up large in the casting shop of this "Bridgeport Brass" plant. But how to exhaust the fumes above the six Ajax electric furnaces during pouring of molten brass had loomed up equally large, as a problem. Pressed Steel Company's wealth of experience in fabricating complicated alloy tubing assemblies in any diameter up to 60" helped solve it. Each assembly, made of No. 10 gauge Type 430 alloy, is 73 feet long and ranges in diameter from 19" to 33". Featuring thin-wall return bends, PSC welded alloy tubing assemblies offer a light-weight method of construction that is introducing large savings in many types of installations requiring corrosion and heat resistance. See how The Pressed Steel Company can help you.

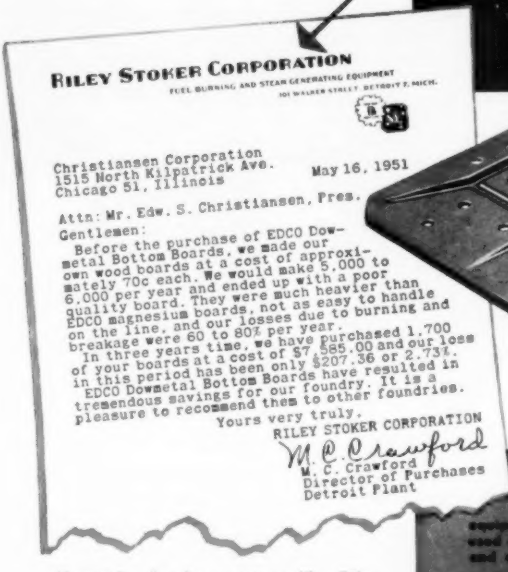
THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆

"EDCO Dowmetal BOTTOM BOARDS have resulted in tremendous savings for our foundry"

...says M. C. Crawford of RILEY STOKER CORPORATION



RILEY STOKER CORPORATION
FUEL BURNING AND STEAM GENERATING EQUIPMENT
101 WALKER STREET, DETROIT 7, MICH.

Christiansen Corporation
1515 North Kilpatrick Ave.
Chicago 51, Illinois

May 16, 1951

Attn: Mr. Edw. S. Christiansen, Pres.

Gentlemen:

Before the purchase of EDCO Dowmetal Bottom Boards, we made our own wood boards at a cost of approximately 70c each. We would make 5,000 to 6,000 per year and ended up with a poor quality board. They were much heavier than EDCO magnesium boards, not as easy to handle on the line, and our losses due to burning and breakage were 60 to 80% per year.

In three years time, we have purchased 1,700 of your boards at a cost of $7,385.00 and our loss in this period has been only $207.36 or 2.73%.

EDCO Dowmetal Bottom Boards have resulted in tremendous savings for our foundry. It is a pleasure to recommend them to other foundries.

Yours very truly,
RILEY STOKER CORPORATION
M. C. Crawford
M. C. Crawford
Director of Purchases
Detroit Plant

Above photo shows molder at Riley Stoker Corporation placing EDCO Bottom Board on flask preparatory to pressing. EDCO DOWMETAL magnesium boards maintain high quality of castings and reduce rejects because the exclusive grooved and vented design permits escape of gasses and insures mold stability.

Progressive foundry operators, like Riley Stoker Corporation, are equipping their foundries with EDCO DOWMETAL Bottom Boards.

Made of magnesium, these boards will not warp or break. There are no nails to come out, nothing to break or split—no upkeep! So durable, they can be considered permanent equipment. The many advantages from the use of these boards are effective immediately on their installation.

Write us or phone CApitol 7-2060 today for complete price schedule and list of 74 standard sizes available from stock.

Riley Stoker Corporation is one of the three largest manufacturers of steam generating and fuel burning equipment in the country. EDCO DOWMETAL Bottom Boards are used exclusively in their foundry in the production of gray iron and alloyed casting components.

Photo at left shows molder pouring sand into flask. Photo at right shows molten metal being poured into molds which rest on EDCO Bottom Boards. Gravity conveyor line carries molds on to further processing.

CHRISTIANSEN CORPORATION

1519 N. KILPATRICK AVE. • CHICAGO 51, ILLINOIS

ALUMINUM ALLOY INGOTS • ZINC BASE DIE CASTING ALLOYS

ANOTHER CHAPTER IN THE HISTORY OF LEPEL

Lepel's NEW HOME

JUST ACROSS THE EAST RIVER IN WOODSIDE, NEW YORK CITY

The new building containing our new factory and offices, designed on the most modern architectural lines, reflects the steady gains made by Lepel for a quarter of a century.

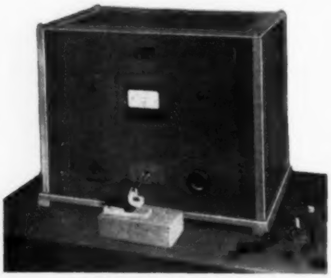
The reputation enjoyed by Lepel in the field of Induction Heating equipment has been made possible by the high quality of the Lepel products and the integrity of the Lepel organization with its pleasant customer relationship.

Lepel

HIGH FREQUENCY *Induction* HEATING UNITS

SPARK GAP CONVERTERS
from 4 kw to 30 kw

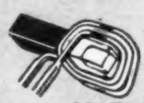
ELECTRONIC TUBE GENERATORS
from 5 kw to 50 kw



LOW COST 2 KW PORTABLE UNITS
Spark Gap operated on 110 volts

ANY LEPEL UNIT DOES THESE JOBS—*faster better cheaper*

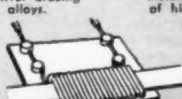
HARDENING
Heat localized exactly where wanted, to any desired temperature up to 5000° F.



BRAZING
Permits widest choice of copper or silver brazing alloys.

MELTING
Readily melts metals and alloys of high melting point.

SOLDERING
Neater, faster, without waste or discoloration.



ANNEALING
STRESS RELIEVING
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For Hot Forging, Hot Drawing, etc.

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WRITE FOR LEPEL CATALOG MP-2

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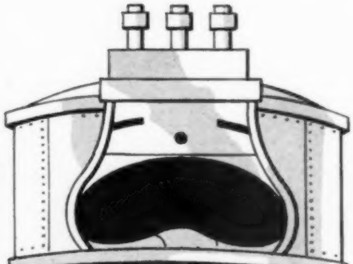

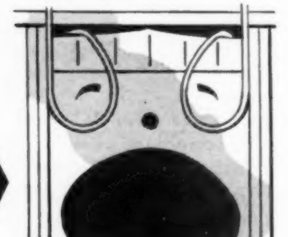

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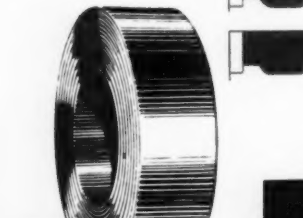

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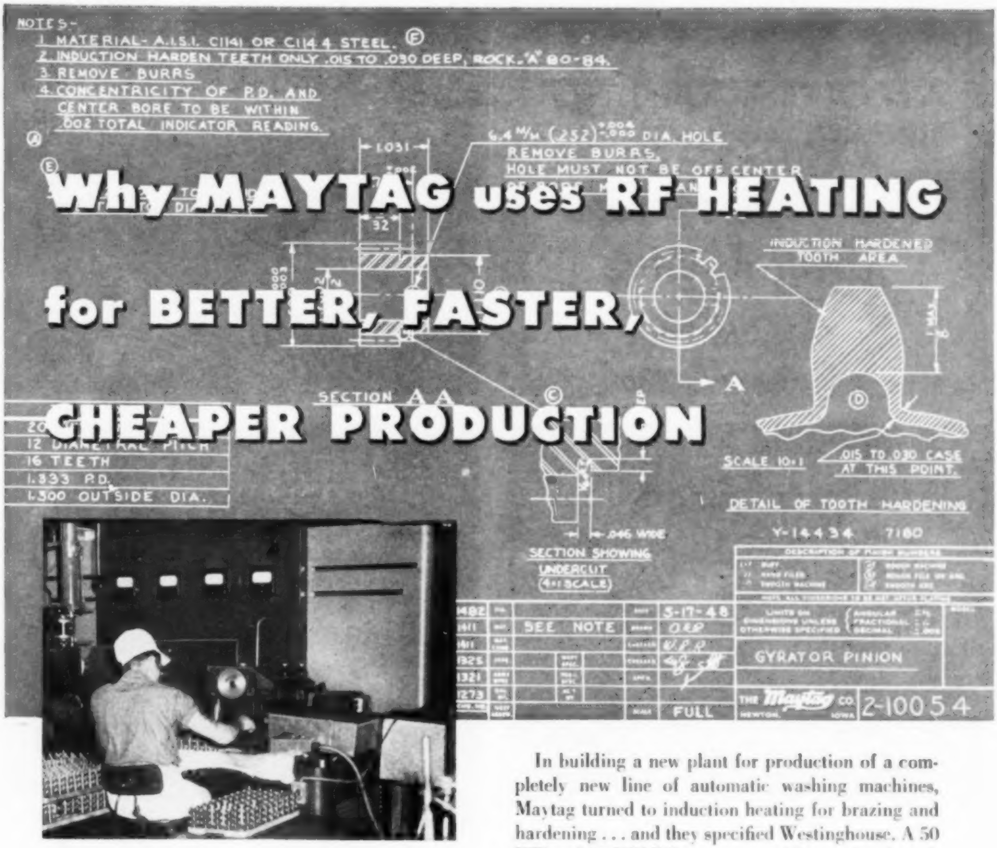

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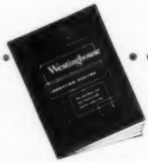

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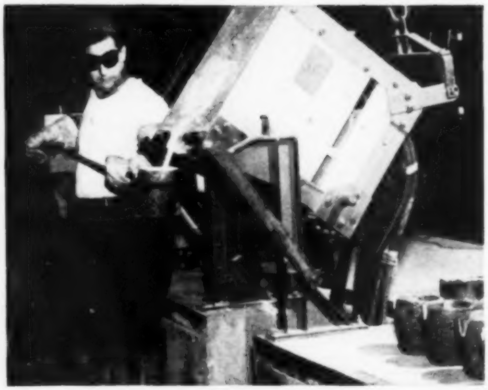

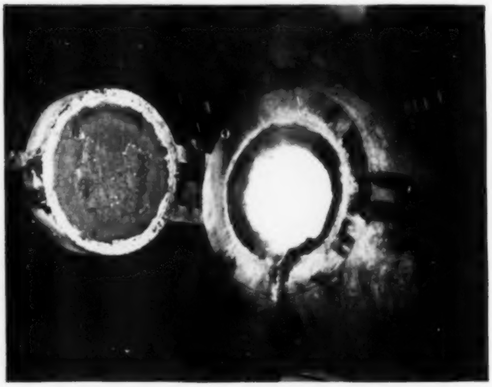

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Metal Progress

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By T. F. Olt and R. S. Burns, director and associate director, respectively
Research Laboratories, Armco Steel Corp., Middletown, Ohio

Improvements in Quality of Deep Drawing Sheet Steel

Manufacture of steel sheets during the present century has grown at a pace considerably above the average rate of growth of industrial production. One reason is that sheet steel has displaced other iron and steel products. Another is the relatively large growth of the automotive, household refrigerator, and metal cabinet industries. Each automobile, for example, on the average, uses 2550 lb. of sheet steel, much of it requiring sufficient drawing qualities in terms of softness, ductility, and gage uniformity to successfully withstand fabrication operations.

The manufacturing methods for sheet steel have been revolutionized during the past 25 years through the development of the continuous rolling mill by Armco Steel Corp. Its perfection and widespread installation by the steel industry, requiring the investment of over a billion dollars, have almost completely supplanted the hand mill. (An exception to this statement would apply to high alloy steels and alloys other than steels, which are usually ordered in relatively small quantities and are still produced on hand mills. The statement is true of low-carbon steel, which is the subject of this article.) During this 25-yr. period the production of sheet steel has grown from approximately 6,000,000 to over 25,000,000 tons. It is an interesting commentary that the cost to a purchaser for cold rolled sheet of drawing quality in 20-gage, 50 in. wide and 96 in. long has simultaneously been reduced from $115 to $104 per ton, notwithstanding the large decrease in the purchasing value of a dollar.

In 1926 most sheet steel was rolled from sheet bars on hand mills (Fig. 1), the productive rate of which averaged about one ton per hour. Labor worked 12-hr. shifts for $4. By contrast, a modern strip mill (Fig. 2) rolls sheet steel at about 200 tons per hr.; labor works 8 hr. for $15 or more.

These revolutionary changes in the steel mill have been accompanied by major changes in quality level and in product uniformity. In fact, most commercial quality sheet steel, as produced in 1952, is far superior in its fabricating properties to the best deep drawing sheet steel available in the early 1920's. Picture, if you can, the vast number of men and hand mills, together with the acres of heating furnaces and buildings, that would be necessary to produce the sheet steel currently required!

Changes in Manufacturing Methods for drawing sheets have been notable. In 1925 they were rolled from sheet bar, box annealed, pickled, temper rolled for surface, given a second box anneal, followed by further temper rolling prior to shipment. The present product as of 1952 is manufactured by hot rolling, pickling, cold reduction to ordered gage, and box annealing, followed by temper rolling to prevent surface disturbances occurring during forming operations in the customers' plants. The transition was made in several stages. With the advent of normalizing furnaces in the middle 1920's the production of sheets for drawing purposes rapidly shifted; the first box annealing operation after hot rolling was replaced by a normalizing treatment. This single change in mill practice greatly decreased the variability of grain size and went far toward eliminating the rough surfaces on stretched sheet metal parts, due to coarse grain.

With the advent of the first continuous rolling equipment in 1923 at the Ashland Division of Armco, the quality of drawing sheets was further improved through the greater uniformity in mechanical properties, surface condition and thickness. Subsequent installation of continuous cold reduction equipment yielded further improvement in uniformity in surface and thickness. Such sheets were classified as "hood and fender deep drawing quality" and "radiator casing deep drawing quality" because of the high degree of perfection in surface uniformity and drawing behavior.

New Methods

Fig. 1 — Hand Hot Mill of 1925 Required Much Exhausting Labor to Roll One Ton an Hour. Selling price of product: $115 per ton in 1925 dollars

Since 1935, the industry has shifted rapidly to the present procedures which are based on hot rolling, normalizing, pickling and box annealing for "hot rolled pickled drawing quality", and hot rolling, pickling, cold rolling, and recrystallization annealing for "cold rolled drawing quality" sheets.

Sheet steel of drawing quality is usually produced with restricted carbon and sulphur content (as compared to commercial quality); selected raw materials are used for melting stock so the sheets will have satisfactory hardness after annealing. This selected steel is cast into ingots which may vary in weight from 6 to 20 tons and even larger. These ingots when suitably heated to 2300° F. are hot rolled to slab thickness ranging from 4 to 8 in. After reheating, the slabs are hot reduced to hot rolled strip, 0.05 to 0.25 in. thick. Coils of 18 gage and heavier are ordinarily rolled to finished thickness on the hot strip mill. Cold reduced sheets are made from hot rolled strip in coils by cold reducing on a cold tandem mill after pickling free from scale.

Both hot rolled and cold rolled sheets are made in commercial quality and in drawing quality; the essential difference is in the restricted chemistry, the extra selection, the extended processing, and the closer quality control that is exercised on the drawing quality sheets. It is not at all unusual to divert as many as 25% of the ingots originally scheduled for drawing quality applications because of deviations from standard practice as regards restricted chemistry, scrap selection, or other anomalies during melting and processing.

QUALITY CONTROL

The transition from production on hand mills has necessitated an entirely different series of sampling and testing practices. The problems of sampling and control at present production rates are of a completely different order of magnitude. The means that have been established to maintain quality levels should be of interest to all users of sheet steel.

In former years samples were merely taken from sheets in the top, middle, and bottom of a charge in an annealing furnace, and cup tested to secure some idea of the degree of ductility and surface coarsening that could be expected during a drawing operation. Very little if any metallurgical control was applied to operations prior to this point in the production cycle — almost immediately prior to shipment. Under present methods the rate of production is so fast that such a procedure would be extremely laborious and greatly interfere with the flow of manufactured product.

At present, the systems of quality control cover all phases of the manufacturing operations and are implemented by metallurgical observers at all processing steps. In this manner the mill can duplicate an order of sheet steel exactly as a satisfactory lot was formerly made. In the event some material passes through any processing step at variance with the established practice, it can be diverted — or specially marked and exhaustively tested on completion to determine whether the deviation from standard quality is sufficient to de-grade the material to less stringent requirements. Knowledge about the properties of material that has deviated from standard practice often enables the mill metallurgists to determine immediately that the questionable sheets when finished will be satisfactory or unsatisfactory for the purpose contemplated. If

there is a reasonable doubt, the sheets can be diverted to a requirement which they will satisfy, and a "remake rolling" can be scheduled without further delay.

As a result of establishing controls over all steps — from the blast furnace through the scrap selection for openhearth charges, steel melting and refining operations, heating, rolling, annealing, and processing — the thickness uniformity, the metallographic uniformity, the surface uniformity, and the uniformity of mechanical properties have been improved to such a degree that, when taken in combination, a much better product is now available as far as its deep drawing behavior is concerned.

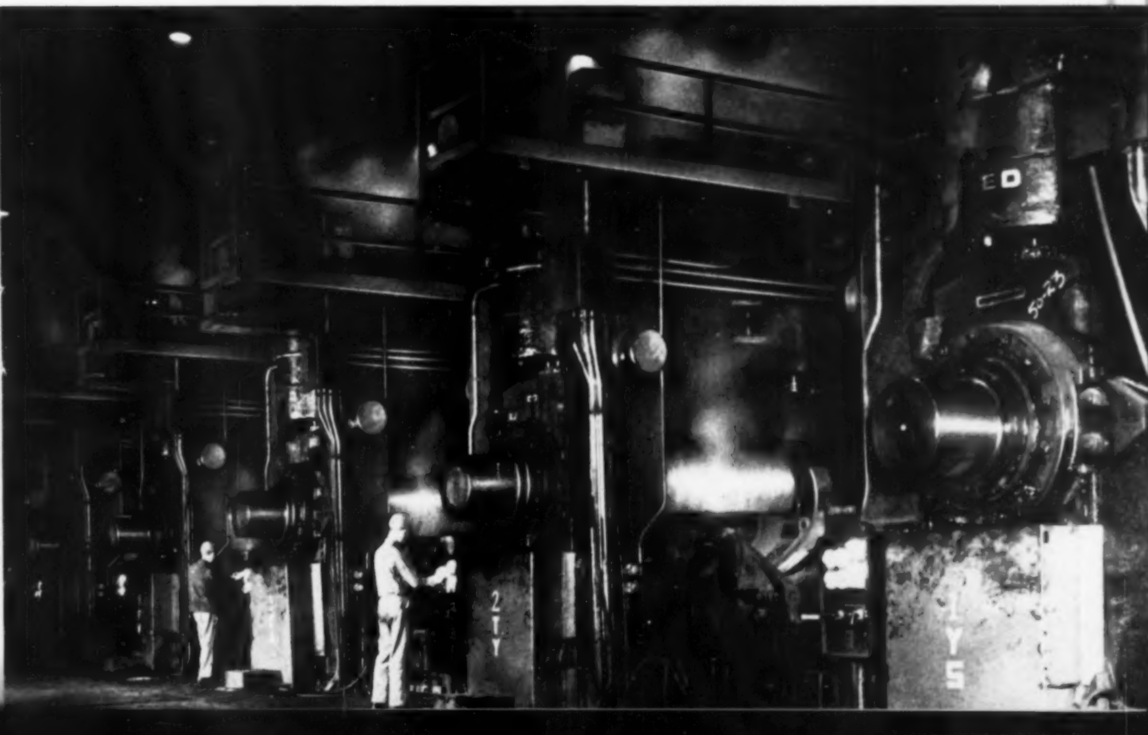
It is only through the establishment of standard manufacturing procedures and quality control that such high levels of quality and uniformity can be maintained at the production rates now current. Such quality control has also ushered in the manufacture of sheets in large coils which, in turn, has enabled the customer to establish his blanking operations in such a fashion as to secure the maximum number of parts from a ton of material with a minimum of scrap.

Variation of Properties — The pressure for economies in the mill and a low selling price has resulted in increasingly larger units; this increases production rates and its corresponding economies. Many mills now convert an entire ingot into a single coil. It is inevitable that variations in the drawing properties of the sheet exist within such a coil. In fact, one might picture sheet steel as uniformly nonuniform, with properties that vary between fixed limits.

Normal Variation in Properties

Rimmed steel is the usual starting material; it results in a product of lowest cost, all things considered. Rimmed steel is more variable in composition between surface and mid-thickness than killed steel; these variables also differ, depending on the time required to solidify. Sheets made therefrom are relatively free from surface imperfections due to heating and rolling. Rimmed steel, because of its chemistry, forms oxides that are fluids at rolling temperatures and pressures; any breaks or tears or other ingot surface imperfections can therefore weld during rolling. This characteristic results in a product having unusually good surface when compared to sheets made from killed steels in which surface breaks do not reweld during rolling due to the presence of such solid oxides as alumina, silica, or both.

Fig. 2 — By 1952 Mechanization Has Eliminated All Severe Labor, and Hot Strip Mills Roll 200 Tons an Hour. Selling price of product: $104 per ton in 1952 dollars



Rimmed Versus Stabilized Steel

As is doubtless well known to most readers of *Metal Progress*, steel is said to "rim" (effervesce) when the carbon remaining in the melt reacts with the dissolved iron oxide as the temperature decreases to the solidification point. This chemical reaction evolves gas which constantly stirs the molten metal in the mold and aids any insoluble matter (along with more fusible portions of the iron higher in carbon and phosphorus) to concentrate or segregate in that portion of the ingot still liquid.

Since the top of the ingot contains the last portion of the melt to freeze, it contains the most segregated areas and the greatest variation in chemistry, as shown in Fig. 4 and the left view in Fig. 5. As the mechanical properties are largely dependent on chemistry, the metal in the top portion is furthest from the general average in mechanical properties. Consequently, it is a rather common practice to discard or divert the top section of such ingots when rolling to drawing quality requirements.

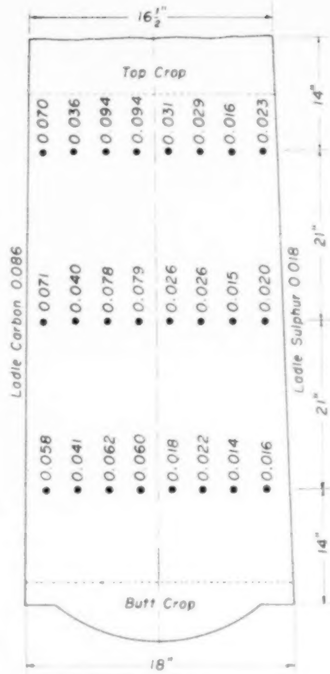


Fig. 4 — Segregation of Carbon (Left) and Sulphur (Right) in a Representative Ingot of Rimmed Steel

USE OF STABILIZED STEEL

Another means of securing a greater degree of uniformity in mechanical properties and drawing behavior is by making special killed or stabilized steel. By adding sufficient strong deoxidizer to the melt the rimming action can be prevented — for example, by reacting the dissolved iron oxide to an insoluble form by additions of aluminum. Under such conditions the metal solidifies quietly in the mold, and this greatly decreases the chemical variation between surface and mid-thickness, and top and bottom of the ingot.

Aluminum-killed steels are much more difficult to manufacture with a high degree of surface uniformity than rimmed steels, for the reasons previously cited; however, marked progress has been made during the past 15 year in effective surface conditioning. This increases the cost; however, the uniformity of properties is much greater than it is possible to secure with rimmed steel (Fig. 5 and 6) even when a large crop is discarded

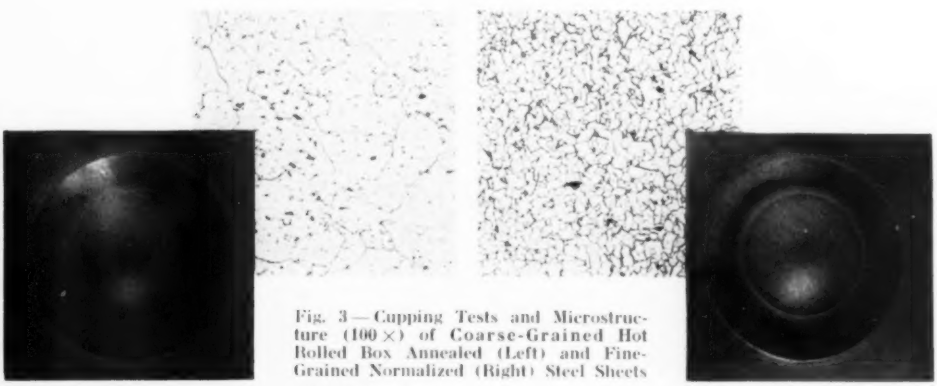


Fig. 3 — Cupping Tests and Microstructure (100 ×) of Coarse-Grained Hot Rolled Box Annealed (Left) and Fine-Grained Normalized (Right) Steel Sheets

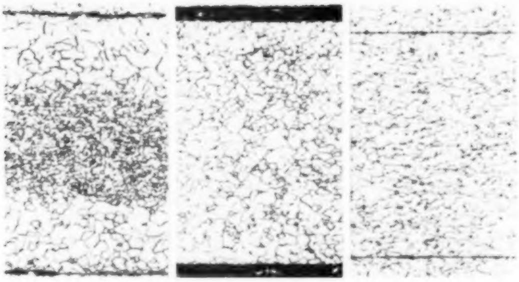


Fig. 5 — Effect of Segregation on the Microstructure of Rimmed and Killed Steel Sheets

from rimmed steel. In addition, after suitable annealing, special killed steel sheets are free from aging behavior and stretcher strains in drawing — objectionable characteristics difficult to control in rimmed steels.

As a result, there is a considerable demand for special killed steel for drawing quality sheets to be used for applications where the cold forming is more severe than a drawing quality rimmed steel can be expected to withstand. This improvement in uniformity can best be pictured by the spread of properties shown in Fig. 7. These distribution curves indicate clearly that the spread between samples with maximum and minimum ductility is somewhat less in killed steel than in rimmed steel — that is, its uniformity is better — also that the average ductility is higher and that the best values are considerably better in killed steels.

UTILITY OF DEEP DRAWING SHEET

Utilization of deep drawing sheet steel has fully paralleled in diversity its expansion of tonnage. In order to increase production rates in the stamping plants, a material was necessary that could be drawn with a minimum of breakage or other objectionable defects. In addition, there has been an increasing trend to combine into one stamping numerous stampings formerly produced individually and joined by various means, such as welding or brazing. An example is large automobile stampings for floor pans, side panels, hood tops, and roof panels. Side panels, which sometimes even include the rear fender, formerly made in a number of parts are now pressed out of one sheet. Fenders which were made in three parts — that is, a crown, an apron, and a hood ledge — are now frequently being drawn in one part. These fabrication procedures have required larger and larger sheets; simultaneously it has been necessary to control uniformity and maximum hardness levels rigidly, in order that the sheet may flow in the dies at low unit stresses, and so prevent buckles and excessive breakage. Utilization of "sheets in coils" has been expanded to allow the blanking of irregular shapes with maximum economy and minimum scrap.

Such improved practices in the automotive stamping field are duplicated by similar gains in such other industries as formed metal plumbing ware, and household appliances such as refrigerators, ranges, washing machines, and dryers, as well as for much hollow ware.

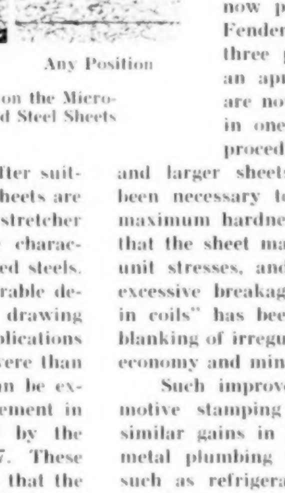


Fig. 6 — Killed Steel Sheet Has Nearly Uniform Hardness Edge to Edge and End to End of Coil

The problems of the sheet steel producer and the sheet steel user are similar. The mill must produce drawing quality sheets sufficiently ductile and uniform to make an identified part at minimum cost. The fabricator demands the highest degree of uniformity and ductility at the lowest possible cost. As both producer and fabricator must maintain high production rates in order to secure low costs, it naturally follows that the producer and the user have had to work in close harmony. The sheet producer contributes to this cooperative effort through mill representatives and metallurgists who visit customers frequently, so that any slight adjustments required in the sheet produc-

tion methods can be made when, as, and if the need arises.

Thus, the producer has a clear understanding of the customer's specific requirements. Cooperation between the consumer and producer has usually been so complete and satisfactory that it has been unnecessary to write restrictive specifications covering the mechanical properties and chemistry of the drawing sheets, the main requirement

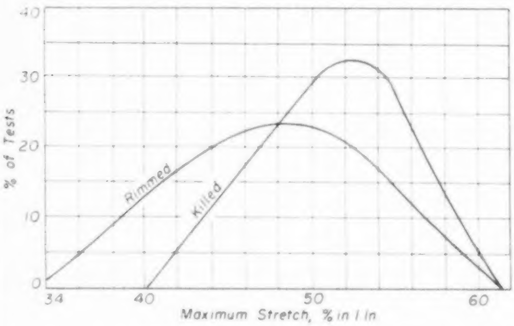


Fig. 7 — Frequency Curves Showing Maximum Stretch (% in 1-In. Gage) of Rimmed and of Killed Sheet Steel of Drawing Quality Indicate Superiority of Latter

being that the sheet must be satisfactory for the job insofar as breakage and surface after drawing are concerned.

This valuable cooperative effort between mill and customer has resulted in intensive competition among the various producers to improve the performance of their products. It is not at all uncommon in automotive stamping plants for the mills to be rated according to the fraction of parts defective on a specific stamping. A producer may find himself in fourth position with a breakage rate of six parts per thousand, when his competitor in first position is delivering sheets with a breakage rate of four parts per thousand.

The manufacture of drawing quality sheet steel is a problem in economics in which the goal of both maker and buyer is a sheet with adequately uniform properties to make the job. Any additional uniformity beyond that point is of little value in improving performance, and can only be provided at extra cost to the consumer. Thus, the problem of satisfying the multitudinous drawing requirements is one of tailoring the sheet to the specific use. It is rather amazing that it has been possible to manufacture drawing quality sheets to satisfy so many varied applications and still make them at a price of only about 5¢ per lb. Where else in American industry can so much quality be secured for so little?

Such a satisfactory state of affairs would not have been possible without the complete cooperation that has long existed between the producer and the user. The benefits of this cooperation have accrued to the nation and contribute in no small measure to our improved standard of living.

WHAT OF THE FUTURE?

When gazing into the crystal ball one's vision is conditioned by what he knows has transpired in the recent past. Users of sheet steel for drawing purposes have always been requesting better materials; they mean more economical manufacture; the crystal ball indicates that this demand will continue. One can be certain that when better drawing sheets are available, they will be used.

It is quite probable that means will be devised to improve still further the uniformity of drawing behavior. This will come about through both metallurgical and mechanical means. The steel industry has undertaken an enormous program of capital expenditure that will provide improved equipment and instrumentation.

We can expect better thickness uniformity through improvement in rolling mills and development of various radiation and electronic measuring devices, operating accurately and almost instantaneously. The instrumentation and controls employed in the shaping and annealing operations are also being improved. Some of the causes of variability, such as segregation of the normal chemical elements and compounds, are difficult and expensive to overcome, but intensive efforts should yield some improvement.

Steel producers are conscious of the possibilities for improvement and are pressing their research and operating organizations to improve the product. Such improvements are likely to be evolutionary rather than revolutionary. So long as the steel producer has competition — that major element in our free enterprise system — to spur him on to satisfy his customers' needs, there is little question but that progress will be made.

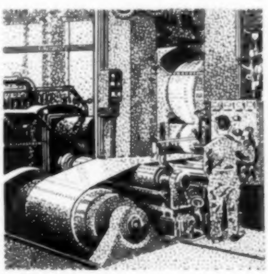
By F. C. Hull, manager of metallurgical section and Howard Scott, manager metallurgical and ceramic dept., Westinghouse Research Laboratories, East Pittsburgh, Pa.

Induction Heating for Continuous Heat Treatment of Sheet and Strip

When in 1942 high-frequency induction heating had been successfully applied to the fusion of electrolytic tin-plate on steel as it emerged from the plating line, other applications were sought in the fields of continuous annealing and heat treatment. Particularly appealing were its possibilities for annealing low-carbon steels for deep drawing and tin-plate stock, and for solution treatment in the processing of age-hardenable aluminum alloys. The best part of a week is required for batch annealing of steel, since the heat must be transmitted to the center and then removed from large coils with a poorly conducting gas film between each turn. Conventional practice for aluminum requires cutting the long coils into relatively short lengths, heating them while suspended in a vertical furnace, and then quenching directly into water with consequent severe wrinkling. With the possibility of improving these methods, work was started on associated problems in the Westinghouse Research Laboratories during 1942 with results briefly described herein.

In order to attain a reasonable rate of production in a continuous heat treating operation, the speed of the strip must be around 100 ft. per min. Running at that rate, strip must be heated within a few minutes or preferably seconds, otherwise the furnaces and conveying equipment reach impracticable sizes. Whether or not such short time cycles will yield the desired metallurgical results can be determined rather easily by laboratory tests. F. T. Hague and P. H. Brace published such an investigation on auto body steel in *Iron and Steel Engineer* (September 1936, p. 47). Using 1725 to 1760° F., an annealing temperature over the critical range, they found that a holding time of 1 min. was adequate but that retarded cooling between 1020 and 840° F. was imperative, otherwise the steel aged excessively. Some 2 min. of slow cooling in this range, so-called "shelf cooling", was required. Even with this added complication, a very effective anneal — comparable with that of bright annealing in conventional bell-type furnaces — was obtained in a total time under 10 min. with radiation heating and fan cooling in a protective atmosphere.

Translating these laboratory data into a production furnace design, two furnaces were built and installed in one of the Ford Motor Co.'s plants. The larger unit bright annealed 7½ tons per hr. of 20-gage auto body stock, 56 in. wide. This furnace, 325 ft. long, illustrates very well the need for faster heating than can be obtained with conventional furnaces. The heating zone, 100 ft. long, could presumably be replaced by a high-frequency heating unit of moderate length, but metallurgical and physical considerations fix the length of the holding and cooling chambers. However, another problem arises, since conventional high-frequency heating becomes inefficient at temperatures above the Curie point (about 1400° F. in low-carbon steel), so we next turned our attention to short-cycle annealing below the critical range.



The materials investigated were low-carbon steel sheets 0.010 in. thick of the grades used for producing tin-plate. For convenience, preliminary tests used a salt bath to achieve a rapid heating rate. Later it was demonstrated that results were comparable to those obtained by actual induction heating

Short Cycle for Low-Carbon Steel

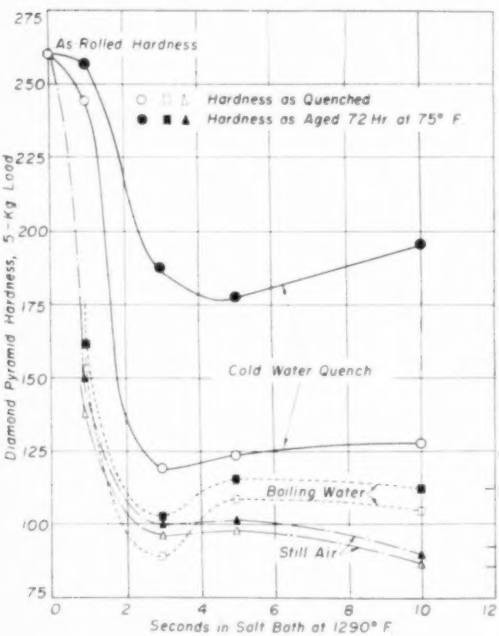
for annealing whereby the steel could be heated to the Curie temperature in $1\frac{1}{2}$ sec.

SHORT TIME IS NEEDED AT TEMPERATURE

Surprisingly, cold rolled tin-plate stock can be softened very thoroughly by holding less than 10 sec. in the temperature range of 1250 to 1350° F. The optimum temperature is believed to be 1340° F. The method of cooling to room temperature *after* annealing, however, determines the initial hardness and especially the room temperature aging tendencies, as illustrated in Fig. 1. (It is assumed that carbon and nitrogen are responsible for aging phenomena in tin-plate stock.)

Two satisfactory methods have been found for rapid cooling to room temperature without adversely affecting the anneal. The first involves quenching or cooling to an intermediate temperature of about 900 to 950° F. and holding for 10 sec. Thereafter, the steel may be quenched in oil or otherwise cooled rapidly; such treatments give soft steel which maintains a diamond pyramid hardness of less than 110 after 12 days' aging. The second method provides for an atmosphere cool for 15 sec. followed by quenching to room temperature by a suitable method. Results are comparable.

Fig. 1 — Tin-Plate Stock May Be Annealed at 1290° F. in 3 Sec.; Hardness Depends on Speed of Quenching. Note also that rapidly quenched sheet age hardens greatly at room temperature. Analysis: 0.08% C, 0.36% Mn, 0.016% P, 0.027% S



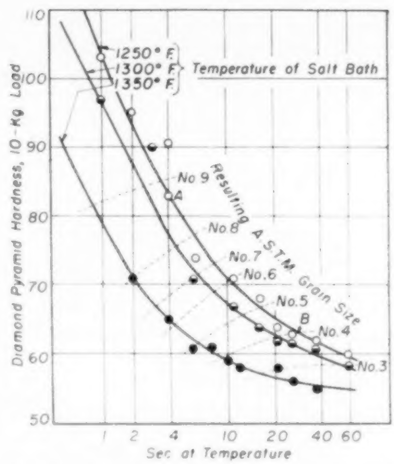


Fig. 2 — Cold Rolled 70-30 Brass Softens and Recrystallizes Very Rapidly in Salt Bath. Log time scale; 4 sec. assumed for heating to bath temperature. Original material: 32-mil sheet, cold rolled 4 numbers hard; initial hardness 178 diamond pyramid, 10-kg. load

Such products annealed on short cycle are inherently fine grained, because they are rapidly cooled as soon as recrystallization is complete and before appreciable grain coarsening takes place. As is well known, fine-grained metals have a higher hardness and yield strength than coarse-grained ones, other things the same. This is the most serious limitation to continuous annealing, but it is reported by people having experience with both products that batch annealing with its relatively soft and coarse-grained product is only required for a few applications, and a steelmaking practice favorable to continuous annealing for minimum hardness can be used for them.

CYCLE FOR BRASS AND ALUMINUM

Other alloys free from the aging characteristic of low-carbon steel offer a simpler application for short cycle heat treatment, particularly annealing. On this basis, several such metals were studied in the labora-

tory, namely, 70-30 brass, 18-8 stainless steel, and aluminum alloys. Brass strip was brought to a temperature of 1250° F. in a salt bath in 4 sec., whereupon the metal was already completely recrystallized to grain size No. 11, as shown at Point A in Fig. 2. The grains also coarsen rapidly, a No. 4 A.S.T.M. grain size being attainable in less than 1 min. at temperature (Point B). Still faster recrystallization and grain growth can be obtained with the higher annealing temperatures shown. Evidently, then, continuous annealing of brass is not limited by the time required for these reactions.

Aluminum offers still better prospects for application of continuous annealing, since it is produced in larger coils than brass. Specimens of cold rolled, 0.020-in. Alclad 24S strip (with a nominal composition of 4.5% Cu, 0.6% Mn, 1.5% Mg, and normal impurities) were heated in a salt bath for various times, quenched, and aged 24 hr. at room temperature before testing.

Figure 3 shows that complete softening required 20 sec. at 650° F. (after 30 sec. the hardness was about the same) and 5 sec. at 750° F. Note, however, that there was a slight increase in hardness from the minimum for the 750° treatment after holding longer than 10 sec. This slight hardening was due to the partial solution of the compound which causes precipitation hardening at room temperature. To avoid such effects, time at annealing temperature above 700° F. must be limited. This phenomenon, however, is used at present to interpret hardness variations across the width of continuously annealed strip in terms of temperature distribution.

Continuous solution treatment of aluminum alloys in preparation for age hardening has even more appeal than annealing for softening or recrystallization, because of the possibility of reducing the distortion encountered in batch quenching operations. To evaluate the time factor involved, 0.040-in. bare 24S sheet, as cold rolled, was heated in a salt pot, water quenched, and aged 24 hr. at room temperature. Results are presented in Fig. 4. Maximum hardness was obtained in 3 min. at 930° F., which checked the cycle

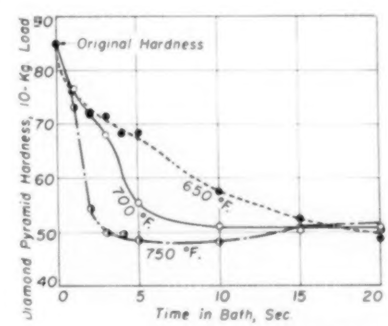


Fig. 3 (Above) — Rapid Softening of Alclad 24S Sheet, Cold Rolled to 20-Mil Thickness and 85 Diamond Pyramid Hardness in Salt Baths of Temperatures Indicated. Plotted tests were made after 24-hr. aging at room temperature

Fig. 4 (Below) — Cold Rolled 24S Aluminum Alloy Sheet, 0.040 In. Thick, Can Be Effectively Prepared for Age Hardening by Heating at 930° F. for 3 Min. and Quenching in Water. Samples aged 24 hr. at 70° F. before testing

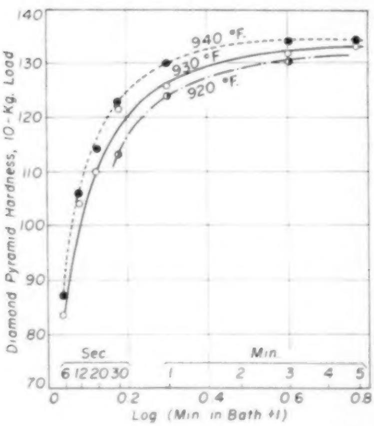
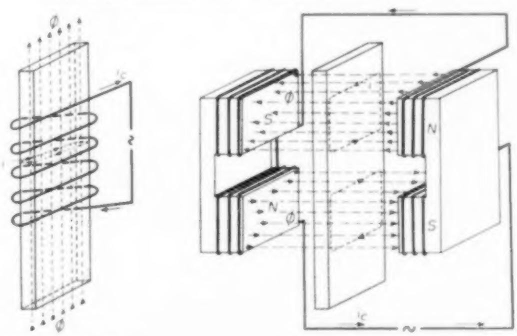


Fig. 5 — Diagrams Showing Longitudinal Flux Induction Heating (Left) Suitable for Ferromagnetic Materials, and Transverse Flux Induction Heating (Right) Suitable for Nonferromagnetic Materials



Longitudinal Flux Induction Heating

Transverse Flux Induction Heating

obtained from tensile data, and the recommendations by Lamourdedieu in *Metal Progress* for October 1951 (p. 88) of 2 to 4 min. at 925° F. Higher temperatures incur danger of grain boundary melting; lower temperatures result in inadequate hardening. Obviously, the temperature is quite critical but the time required is short enough for practical use.

Recognizing that high-frequency induction heating (over 10,000 cycles per sec.) with longitudinal flux is ineffective when applied to nonferromagnetic strip materials, R. M. Baker, at that time in the Westinghouse Research Laboratories, undertook the development of a more efficient continuous process. "Longitudinal flux induction heating" is the type of induction heating familiar to most metallurgists. As illustrated in Fig. 5A it is characterized by the fact that the magnetic flux produced is parallel to the longitudinal direction of the workpiece. The high permeability of magnetic steel strip permits an effective concentration of flux in such material and efficient heating occurs.

Its limitation when applied to nonferrous metals and austenitic stainless steels is that the small cross section of the nonferromagnetic strip intercepts only a very small percentage of the total flux through the inductor coil. Baker overcame this difficulty by developing so-called "transverse flux induction heating" shown in Fig. 5B, wherein the magnetic flux is directed perpendicularly to the surface and through the strip, instead of along its length. Soft magnetic pole pieces are used to concentrate the magnetic flux. The new system was fully described by him in *Transactions* of the American Institute of Electrical Engineers in 1950 (Vol. 69-II, p. 711), and strangely enough (to a metallurgist) heats 54-in. aluminum

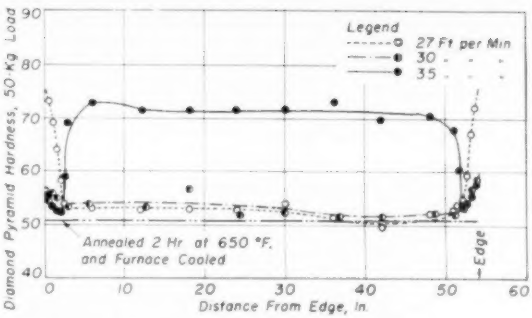
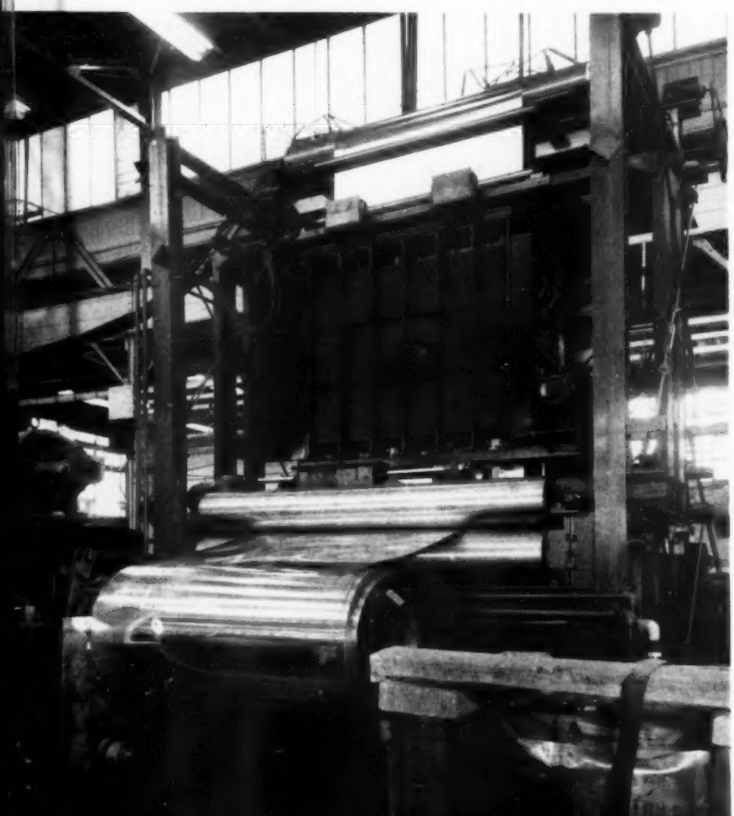


Fig. 7 — Hardness Traverses of 0.040-In. Aluminum Alloy (24S) After Going Through Unit Shown in Fig. 6 at Various Speeds. Hot edges were avoided at 30 ft. per min. by blowing cool air against them while within the heating coils

Fig. 6 — 300-Kw. Experimental Unit Available in 1944 for Induction Heating 54-In. Aluminum Alloy Strip by Transverse Flux



sheet rapidly from a 60-cycle power supply with an efficiency of 80% or better.

Two 300-kw. pilot units using transverse flux induction heating have been built. The one shown in Fig. 6 was available in 1944 for experimental use. Cold rolled Alclad 24S strip, 0.040 x 54 in., was heated for annealing in this unit at various speeds and quenched directly in water as it emerged from the heater. No indication of warpage or wrinkling could be noticed either as the strip entered the water or passed onto the coiler. There was no furnace available for soaking, so the material could not be held at maximum temperature. Hardness traverses were taken across the width, with results as shown in Fig. 7. No means were available for measuring the maximum temperature attained, although the temperature distribution can be inferred from Fig. 3.

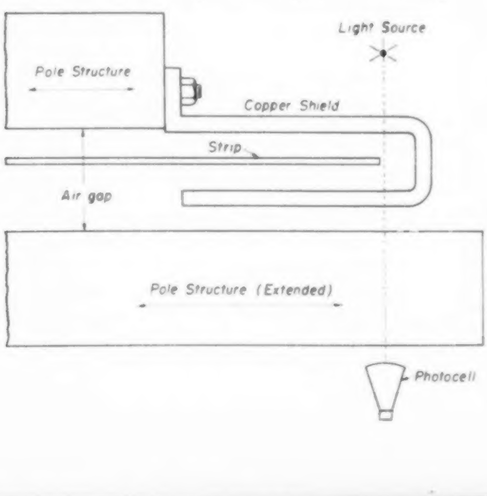
PREVENTION OF SOFT EDGES

A uniform hardness was obtained across the strip except at the edges, indicating that a uniform temperature distribution existed across the central portion of the strip. At 27 ft. per min. the strip was fully annealed in the center and overheated at the edges. At 35 ft. per min. the temperature reached was insufficient for full annealing, except at the edges, which obviously were hotter than the center. However, when the center was properly annealed, the edges were harder — due to age hardening resulting from the solution effect of heating to a temperature over 750° F. Hot edges were partially avoided by blowing air against them. With this expedient a nearly uniform hardness across the full width was obtained at 30 ft. per min.

To avoid overheated edges in production installations, and for adjustment to actual strip width, Baker moved the poles laterally relative to one another, so the flux through the strip's edges was the same as at the center. By means of photocells placed just ahead of the inductors this adjustment was fully automatic, as illustrated in Fig. 8.

Another correction which also had to be made was for magnetic instability. Without such a correction, nonferromagnetic strip pulled over against the extended pole pieces due to electrical currents induced near the edges. This effect was nullified by attaching U-shaped copper shields to the edge of each pole structure, as shown in Fig. 8. These modifications and improvements were incorporated in an 1875-kva. transverse flux inductor coil designed and built by Westinghouse for continuous heat treatment of aluminum alloy strip in production, a part of the line designed and built for a French mill by the United Engineering and Foundry Co. and described by Lamourdedieu. The transverse flux heating coil raises the strip temperature almost to the temperature of the holding furnace.

Fig. 8 — Device for Avoiding Hot (or Cold) Edges Includes Lateral Movement of Poles, Controlled by Photocells at Either Edge. Copper shields at edges prevent magnetic instability



The final hurdle to be cleared in the continuous heat treatment of nonferromagnetic alloy strip is temperature measurement. Our data show that close control is imperative, particularly for the solution treatment of age hardening aluminum alloys. Lamourdedieu's article in *Metal Progress* indicates that this problem has been solved — at least to the satisfaction of one customer — by Leeds and Northrup in collaboration with United Engineering and Foundry Co.

Obviously, the technical knowledge is now available to heat treat economically and continuously wide strips of nonferromagnetic metal. Full-scale equipment has been set up and run experimentally in this country at two locations. The unit built by the United Engineering and Foundry Co. is now being installed by the Central Society for Light Alloys in France. Production experience there may provide the impetus for more widespread use of this significant advance in processing equipment.

By M. D. Stone and E. A. Randich, United Engineering and Foundry Co., Pittsburgh

Continuous Furnace for Fast Annealing of Tin-Plate

In general, the best applications for continuous annealing are those that have several operations which can be combined into a single one (such as continuous galvanizing, including annealing), where metallurgical requirements are not as demanding as for deep drawing steel, and where production capacities are in the neighborhood of 15 tons per hr.

Continuous annealing of tin-plate was first investigated by Crown Cork and Seal Co., Baltimore, about 1940. (Tin-plate is used by this company for its own bottle crowns and similar products that do not require the lower tin-plate tempers.) To obtain any sort of tonnage at reasonable speeds with the thin strip being processed, Crown Cork adopted what has been termed the "tower type" of furnace. The floor space required for the line is reduced to acceptable values by passing the strip vertically over upper and lower idlers located within the furnace. This type of furnace, provided with cooling ducts and using a "bright" atmosphere, had been used some years earlier, about 1936, at the Midland plant of Crucible Steel Co. for an experimental process for dual coated electrolytic strip. However, the purpose of Crucible Steel's furnace was primarily to fuse the coating and only secondarily to anneal the strip. The second line that Crown Cork and Seal Co. soon installed had a top operating speed of 300 ft. per min. compared to 200 for the first; it provided the next logical step toward economy.

Dominion Foundries and Steel Co. of Hamilton, Ontario, put into operation in 1945 a line designed by Crown Cork. This furnace provided the low-temperature annealing within a short cycle (approximately 90 sec.) deemed so necessary. Its heating section consisted of four 34-ft. vertical passes, and the holding and cooling section had eight 38-ft. passes; about 500 ft. of strip was in the furnace. A major improvement in the Dominion installation was the addition of a chemical cleaning section as an integral part of the equipment, located immediately ahead of the first looping pit. A cleaner product resulted because oil, which burned off to form carbon deposits on the strip, was removed by the cleaning section.

The relationship of the degree of cold work of a low-carbon steel and of the recrystallization temperature was early recognized as an important aspect of the process. The 80 to 90% cold reduction used in tinplate requires annealing temperatures of only 1250 to 1350° F., as compared to 1750° F. for sheet reduced 55 to 65%, as is usual in sheet manufacture. By 1945 many of the problems which had existed in the early '30's were ironed out so that subsequent effort could be devoted to the subsidiary economic factors. One of the first moves in this direction was to substitute gas firing for electric heating to reduce energy costs. With further increases in line speeds — and consequently the production rate — the investment costs per ton of capacity as well as labor costs were further reduced.

The first of the lines put into operation in the summer of 1951 at Gary Sheet and Tin Mill of U. S. Steel Co. incorporates all of the factors that must be considered in the successful processing of a high-production, low-cost product. This line for finished tinplate and black plate can handle cold rolled strip in thicknesses from 0.0075 to 0.015 in. and widths of 18 to 37 in. at a speed of 1000 ft. per min. Its capacity is approximately 30 tons per hr. for an average strip 0.0010 x 30 in. at 1000 ft. per min. The general arrangement of the line is shown in Fig. 1.

CLEANING AND FEEDER SECTION

The operations performed throughout the length of the line are grouped within three general zones — the uncoiling, furnace and recoiling areas. Two uncoilers of the expanding mandrel type are used and these are hydraulically adjustable laterally for variable coil width and automatic strip cen-

tering. A spotlight device indicates where the edge of the strip is to be located, and centers the coils on the uncoiler drum. These coils, incidentally, have an i.d. of 16½ in., an o.d. of 66 in., and weigh 30,000 lb. maximum.

A pinch roll unit feeds the strip to the double upcut shear. The uncoilers are automatically aligned by a side register device which displaces the units laterally with respect to the center line of the furnace. The units that follow are a double seam welder, an edge scanner to warn of badly cracked edges and bad shape, and an air-operated pinch roll unit. The latter, mounted just before the cleaning section, is used to establish a by-pass line to the main entry pulling bridle if the cleaning section is being serviced.

The vertical cleaner tank has four electrolytic passes and two nonelectrolytic passes, and gives the strip about 3 sec. in the former and 1½ sec. in the latter when strip is passing at 1000 ft. per min. A four-brush scrubber follows, the brushes working on the strip together with hot water sprayed under pressure.

The last unit of the uncoiler zone is the hot rinse tank. This has a pair of wringer rolls at the entry side which "squeegee" the strip of carryover from the scrubber to prevent contamination of the rinse water. The strip loops around a submerging roll in the hot water after being sprayed by high pressure jets at the entrance side of the tank, the spray treatment being repeated at the exit side of the rinse tank. Two sets of wringer rolls remove the water from the strip as it leaves the tank. This cleaner provides the full equivalent in cleaning capacity of the conventional separate cleaning lines generally in use. (The entire cleaning system was built by the Hanson-Van Winkle-Munning Co.)

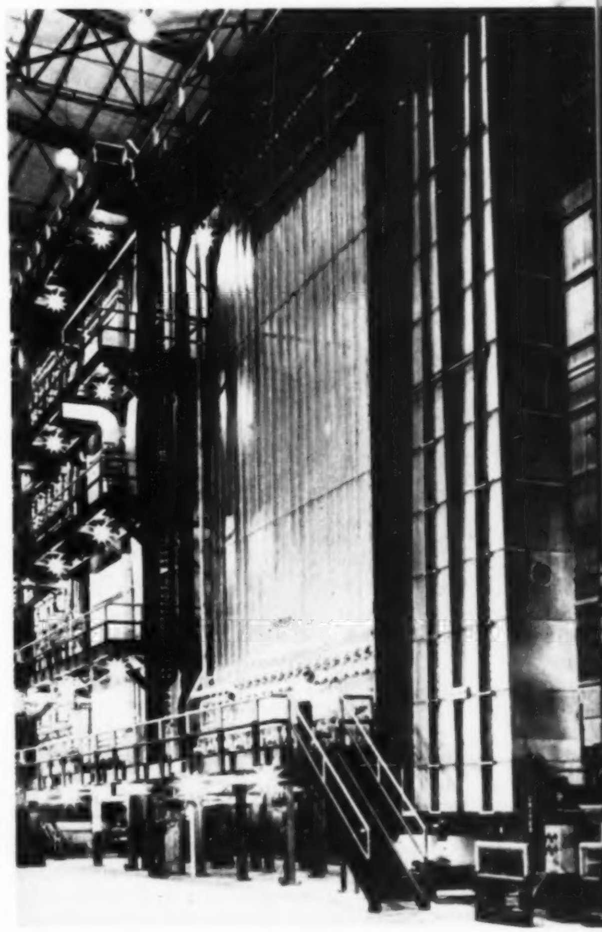
Located immediately above the hot rinse tank is a quadruple-head V-type steam heated air dryer, and from here the strip passes to the No. 1 tension unit.

Next is a 60-ft. looping tower, together with the 30-ft. looping pit, which provide temporary storage for some 360 ft. of strip. The two pinch roll units on the tower are equipped with roller side guides that are electrically controlled from floor level; a weighted cable and calibrated indicator device indicates the guide position. Loop control is by photo-electric eye, modulated type.

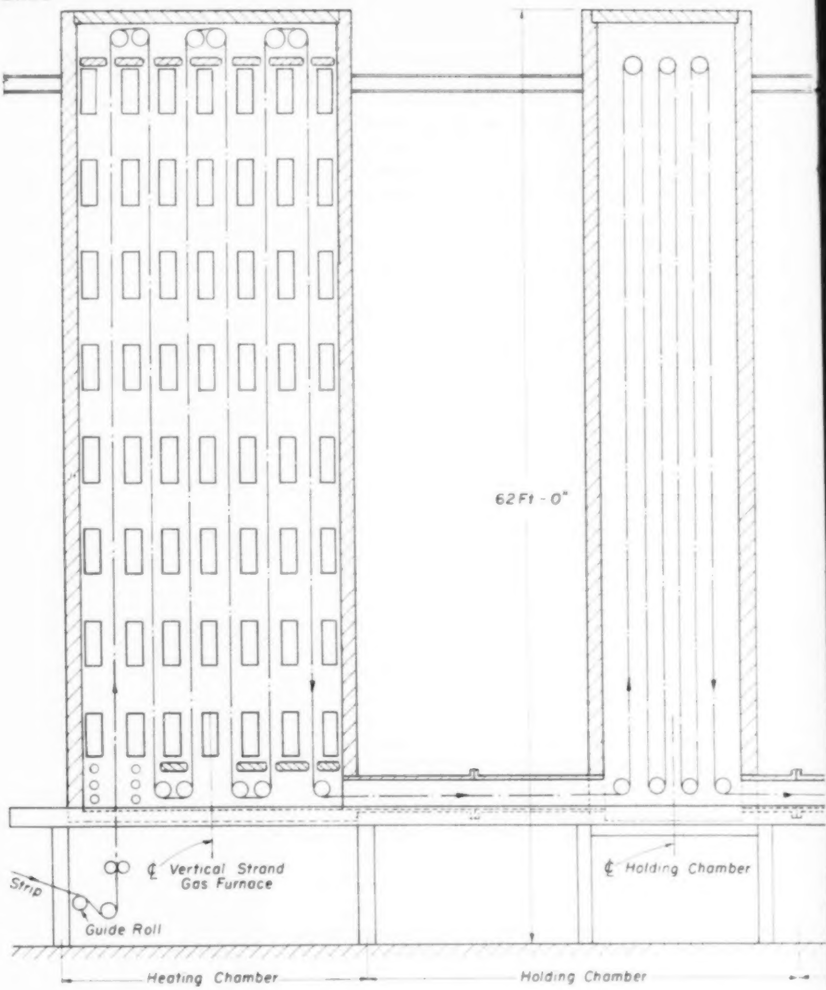
Auxiliaries at Leading End

In the next or furnace zone of this production line is the No. 2 tension bridle which provides the proper back tension to the strip before it enters the furnace. Tension is controlled by a movable roll, actuated through a rack and pinion, the latter driven by a torque motor whose field is varied by a rheostat connected to a "drag tension" bridle. This bridle is caused to speed up or slow down by a signal transmitted from a light beam that is intercepted by a tension roll floating on a loop in the strip line.

General View of Furnace; Heating Zone at Far Left, Holding Zone Next (Both Surrounded by Galleries) Fast Cooling Zone, and Air Blast Towers



The Furnace — Entrance

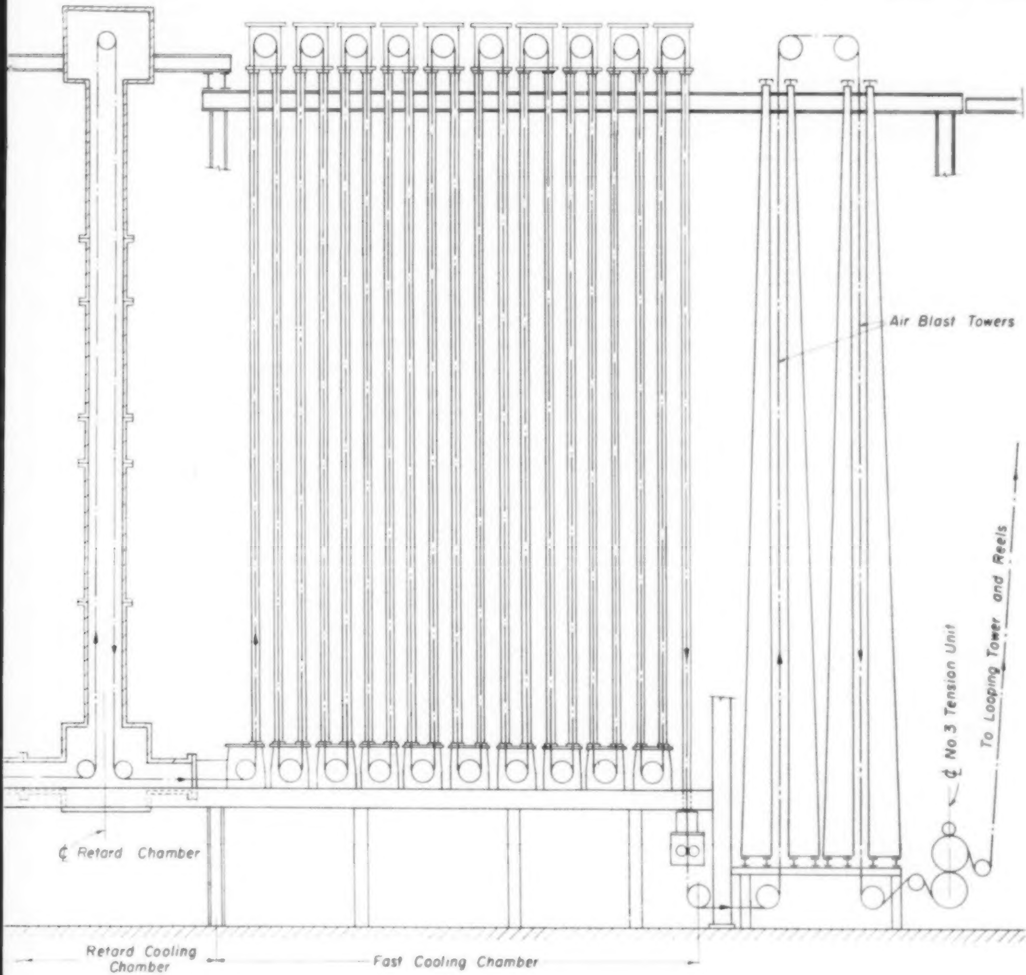


General Cross-Sectional Drawing of Heating and Cooling Units

Heat Treatment Furnace The furnace, built by General Electric Co. in cooperation with Surface Combustion Corp., is a combination gas and electric unit with a capacity of 40,000,000 B.t.u. per hr. in the gas heating section and 925 kw. in the holding and cooling sections. Its thermal cycle is 20 sec. for heating to temperature, a 15-sec. hold in the electrically heated chamber, and a 15-sec. slow cool to about 900° F. This is followed by a rapid cool to 200° F. as the strip passes through a series of vertical, water-cooled ducts. Strip is in the furnace about 105 sec. Before going into the reeling zone the strip is further cooled, first for about 7 sec. in an air blast and then for about 15 sec. in relatively still air, so that the final temperature at the time of reeling is about 125° F.

The first section of the furnace is the heating section (fired by coke oven gas) which provides for six passes of strip. About 325 ft. of strip is constantly in this unit. Burning gas passes through radiant tubes (25% chromium, 12% nickel) designed for a maximum temperature of 1850° F. and for continuous operation at about 1750° F. The

The Furnace — Exit



rolls in this portion of the furnace are centrifugal castings of the same alloy. Six "Rayotubes" are used for temperature control.

The next, or holding chamber, has a maximum heating capacity of 700 kw., and keeps the strip at temperature for about 18 sec. at top speed. It contains six passes of strip, corresponding to about 300 ft. Electrical resistors are divided into four zones of control, with the two main circuits arranged for reconnection for low power during normal operation, high power being used only to accelerate the initial heating-up period. During high-speed operation practically no heat needs be added to this chamber.

The third, or retarded cooling chamber, has 225 kw. of heating capacity for the two passes of strip which correspond to about 100 ft. of length. At top speed, the strip is cooled to 1200° F. in 6 sec. Actually, the total "controlled" cooling zone extends into the first part of the next, or fast cooling, chamber where 900° F. is reached in about 9 sec. more.

The final chamber for fast cooling to

Auxiliaries at Exit End

200° F. consists of a series of 20 individual water jacketed ducts. It takes the strip about 60 sec. to traverse these passes, the total length being 1025 ft. Two blowers recirculate the protective atmosphere so as to create considerable turbulence and thus accelerate the heat transfer from hot strip to water-cooled walls.

Approximately 12,000 cu.ft. per hr. of "Neutralene" or "NX" (93% N_2, 5% H_2, and 2% CO) protective atmosphere is contained in the various zones. This gas produces a cleaner strip than that obtained with earlier atmospheres; in addition, its high nitrogen content eliminates the hazard of gas puffs or explosions.

The final section is the external blast air cooling tower which handles about 120 ft. of strip. Here again the strip passes vertically, this time between wind boxes that are equipped with slotted nozzles.

EQUIPMENT AT EXIT END

Proceeding further, we come to the No. 3 tension unit, the opposite number of the unit at the entry end of the furnace section. Next comes the delivery looping tower, for storing strip when the delivery zone is temporarily stopped. There are three pinch roll units mounted on top of the tower, fitted with guide units and controls similar to those on the entry looping tower.

The recoiling zone has, first, the No. 4 drag tension bridle, which is similar in every way to the No. 2 bridle, to provide back drag against which coils are wound under controlled back tension. Other recoiling equipment consists of an air-operated sample punch, an air-operated, upcut snip shear, re-wind reels complete with hydraulically actuated strippers, coil cars, side register devices (photocells), air-operated flipper gates, and upenders.

The entire line is driven from a single 600-hp. motor-generator, delivering direct current to each of the three operating zones. Driving the various pieces of equipment are some 90 direct-current motors, comprising a total of 1500 hp. of installed capacity and varying in size from 1 to 225 hp. Constant-speed equipment is driven by 50 alternating-current motors with total installed capacity of 1250 hp. In general, the main strip carrying rolls are individually motor driven from the main motor-generator set, including some 15 cleaning section rolls and 49 furnace rolls.

The entire line is 321 ft. long by 43 ft. wide (including control stations) and 65 ft. high at the furnace and looping towers. The line has exceeded its maximum rated production of 30 tons per hr., and it is anticipated that its annual output will be above 200,000 tons. While the stiffer tempers are more easily and economically produced by the continuous method than by batch annealing, it is not beyond expectation that the fine-grained product of the new furnace will also be suitable for the softer tempers because of its favorable drawing qualities and its greater uniformity. A more satisfactory surface condition is another desirable aspect of continuously annealed tin-plate. Absence of "stickers" and the smaller reduction in temper rolling are significant economically.

A dividend of the continuous anneal is the improved flatness of the product leaving the line as compared to its condition when coming to the line from the tandem mills, this being due to the slight stretching the strip receives in the hot furnace zone. Reduction in in-process inventory from seven days to three days, and eventually to one day, is perhaps the dominating consideration in favor of the continuous process; however, evaluation of other economic factors, some of which are given in the accompanying tabulation, must also be included if a just comparison is to be made.

Conclusion — Continuous annealing of tin-plate is on a firm economic basis. In fact, the new Fairless plant of the United States Steel Co. will soon start operation of a quite similar line (slightly wider and differing only in some few minor details) to the one described here.

Comparative Requirements of Continuous and Batch Cleaning and Annealing*

REQUIREMENT	CONTINUOUS	BATCH
Floor space	22,000 sq.ft.	36,000 sq.ft.
Equipment investment charges at 10% per year	$1.00 per ton	$0.80 per ton
Fuel (gas) consumption	700,000 B.t.u. per ton	900,000 B.t.u. per ton
Neutral atmosphere	500 cu.ft. per ton	1000 cu.ft. per ton
Direct labor	0.25 man-hr. per ton	0.33 man-hr. per ton

*Based on production of 200,000 tons per year.

By N. H. Polakowski, University College, Swansea, Great Britain

Roll Size Effects in Rolling of Strip

Why roll diameter limits the maximum draft and minimum thickness but has no important effect on the power required per ton of thin strip rolled.

In many instances, straightforward cold rolling of sheet and strip to the desired final thickness is either impractical or entirely impossible. The limitation lies usually in the mill itself. At some stage of reduction, the maximum drafts which can be taken become too small for economical rolling. (Finally the mill ceases to reduce at all, even with the heaviest screw-down pressure.) In practice, when this condition is approached, the material is softened by heat. Several intermediate anneals are sometimes required before the specified thinness is reached. Such procedure is obviously costly and contains potential metallurgical dangers, because sensitive materials (such as high-carbon strip for springs and band saws) may suffer through surface decarburization or grain coarsening.

It is better to roll the strip to an intermediate gage on a conventional mill, anneal, and finish on another mill with rolls of much smaller diameter. Alternatively, rolling is exclusively on a mill with small rolls; rolling often starts with strip 0.07 to 0.15 in. thick and finishes at several thousandths of an inch without any intermediate anneals. These methods are now commonly used for stainless and high-carbon strip.

A number of explanations have been put forward to explain the extraordinary "reducing capacity" of small rolls. For example, it was claimed in Steckel's original patent that small diameter rolls work harden less for equal reductions than large rolls, but this is since known to be untrue. Quite recently, E. E. Schumacher of Bell Telephone Laboratories, in an address before the British Institute of Metals, ascribed the phenomenon to the high pressure resulting from the very small contact area. Others thought that small rolls cause less friction. The Editor of *Metal Progress* in a "Critical Point" printed 12 years ago (July 1939) speculated that the main reason lies in the correct proportion between roll diameter and strip thickness. It will be shown that the last idea is essentially the correct one.

Furthermore, it is surprising at first sight that the rolling energy for a given reduction (in hp-hr. per ton) is practically the same for a Sendzimir mill with 2-in. work rolls as for a large tandem mill with 20-in. rolls. This fact is directly contradicted by any known theory of rolling. (See, for example, a series of comments on "Off-Gage Strip", in *Iron and Steel Engineer* for October 1950.)

An explanation of both of the problems just formulated is advanced below.

Apparent and Natural Yield Strength — Take a low-carbon steel rod with, say, 35,000-psi. tensile yield strength, and machine from it several small cylinders of equal diameters D but with decreasing heights H, so that D ÷ H = 1, 2, 5, 10, 30, and so on. Now squeeze one after another in a testing machine and observe the beginning of yield in each (Fig. 1).

With the tallest cylinder (D/H = 1) the compressive yield strength Y_1 will be almost exactly equal to the yield strength in tension, but the shorter ones will exhibit increasing yield values, Y_2, Y_5, Y_{10} . . . If a sufficiently thin disk is prepared with a high D/H ratio — for example, cut from a piece of very thin annealed steel sheet — one may find that yielding (plastic flow under compression) does not start even with the compression machine loaded to capacity. Such a sample will be no harder than it was prior to the experiment, thus showing that a very high "apparent" yield strength is not necessarily associated with work hardening.

Similar results can be produced by careful experimentation with metals which have no clearly defined yield, such as copper, brass, aluminum, and even lead. Nevertheless, high "apparent" yield strengths can be easily produced with these metals by taking sufficiently short (or, rather, thin) samples so they have high D/H ratios. Engineers

Apparent Yield Strength

take advantage of this phenomenon when using high-pressure gaskets made of soft copper or lead.

This resistance to deformation of short metal cylinders is due to restraint caused by friction between the squeezed metal and the hard compression plates. The smaller the free peripheral area of the sample compared with its cross section, the more the effort needed to force metal through the narrowing gap between the plates. If friction could be eliminated, the yield point would be the same for any cylinder or disk of a single metal in a fixed metallurgical condition, irrespective of whether the D/H ratio is 1, 10, or 10,000.

The yield strength measured under frictionless conditions can be termed the "natural" yield strength. By using a subterfuge the writer determined its values for many steels and nonferrous metals in many cold worked conditions up to 85 to 95% compression. In one case the natural yield strength of a 0.9% carbon steel, 90% compressed, was about 180,000 psi., and only 55,000 psi. as annealed. But a disk 1 in. in diameter and 0.05 in. thick prepared from the annealed material did not yield under a 170,000-lb. load, thus having an "apparent" yield strength of something over 210,000 psi. — four times as much as its "natural" value, as annealed, of 55,000 psi.

From the above it is evident that the load required to start plastic compression is determined by three factors — first, the natural yield strength, which depends on the nature of the metal and its metallurgical condition and history (annealed, cold worked, heat treated); second, the geometrical proportions of the compressed body (here D/H); and third, the coefficient of friction between the sample and the tools. These rules also apply to broad strip squeezed between two anvils (Fig. 2) where the ratio of contact length to thickness, L/t, is equivalent to D/H in the previous examples.

Summing up: With a given pressure more percentage deformation is obtained if the squeezed metal is softer, or if its thickness increases (other dimensions remaining unaltered), or if surface friction is reduced. In symbols: "Apparent" yield strength is determined solely by the D/H or L/t ratio for any particular metal and fixed coefficient of friction against rolls or anvils.

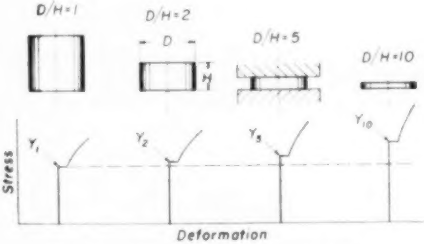


Fig. 1 — Apparent Yield Point of Metal Cylinder Under Compression Rises as the Ratio Diameter-to-Height Increases

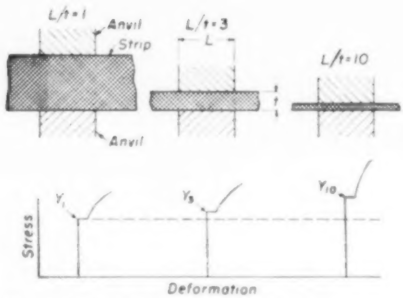


Fig. 2 — If Broad Strip of Thickness t Is Squeezed Between Narrow Anvils of Width L, the Apparent Yield Point of the Metal Under Compression Rises as the Ratio Between Anvil's Width and Strip Thickness Increases

Compression Between Stationary Rolls — In Fig. 3, a metal strip t_o thick has been freely entered between a pair of stationary rolls and progressively compressed by turning the screws. At first, the rolls immerse into the strip; in the condition indicated by Contour I, the length-to-thickness ratio, L_1/t_1 is 1.72. (The *average* thickness "t_1" is less than the original t_o, but greater than the actual minimum on the center-line of the rolls.) From Fig. 1 it is seen that for L/t = 1.72, the apparent and the natural yield strengths differ very little.

When the screws are tightened further, the rolls assume positions No. 2, 3, 4. Simultaneously, the L/t ratio increases, both on account of deeper penetration of the rolls into the strip, and of the increased L due to the elastic deformation of the roll face ("roll flattening", as indicated by Contours II, III, IV). Assuming a constant coefficient of friction between strip and rolls, the progressive increase of L/t, combined with work hardening of the metal being deformed, is accompanied by a rapid growth of the apparent yield, as shown by the curves of Fig. 1 and 2.

It is easy to see that at some advanced stage of this process the apparent yield of the strip must exceed any possible roll pres-

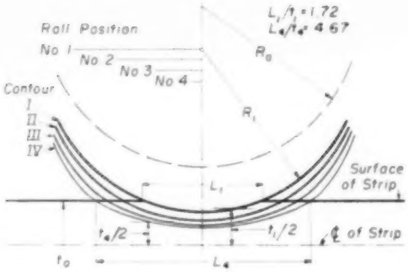


Fig. 3 — Diagram Showing How Ratio L/t Increases as Rolls Are Screwed Down on a Piece of Stationary Strip

sure. (When that point is reached it is impossible to bring the rolls closer together.) More precisely, the apparent yield strength of the strip increases exponentially with rising L/t ratios, at first very slowly but at a rapidly increasing rate, as shown in curve Y, Fig. 4. However, the *average* roll pressure increases simultaneously at a much slower rate, as shown by curve P in the same figure. Consequently, when the actual L/t value reaches x, where the two curves cross, additional tightening of the screws will not reduce the minimum thickness already attained.

By repeating the experiment diagrammed in Fig. 3 with a sufficiently thin strip, one may find that no reduction at all is obtained with even the heaviest pressures. In that event L/t is larger than x in Fig. 4 from the very beginning, so that no plastic compression occurs. Such a state is known to workmen as "rolling the roll"; it has been investigated by Keller (*Blast Furnace and Steel Plant*, 1937, p. 1110).

Curve Y in Fig. 4 refers to metal initially in the annealed condition. If the metal were initially very hard its curve would be displaced up and to the left and curves Y and P would not intersect at all — that is, the rolls would produce no permanent deformation no matter how strongly they were pressed together. (It may be mentioned that curve P for a tungsten carbide roll rises more sharply than the one shown: this indicates that much harder metal can be deformed with rolls made of carbide which flatten less under a given pressure.)

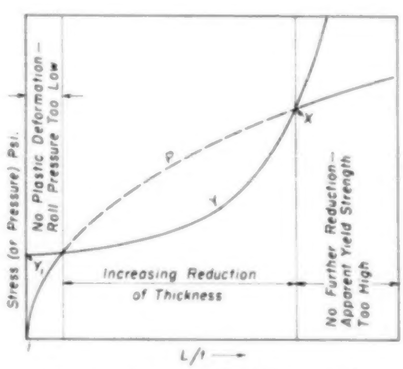


Fig. 4 — Apparent Yield Strength Increases Exponentially With L/t Ratio (Curve Y), and Average Roll Pressure Inversely (Curve P). Beyond point x, intersection of these curves, rolling mill cannot reduce thickness of strip

Compression Between Rotating Rolls — The above discussion was for screw-down pressures on dead rolls. When the mill is running, the apparent yield strength of the metal pinched between the rolls is determined by the L/t ratio for any given material and coefficient of friction, t being the average thickness over the contact length between strip and rolls.

It can be shown in an elementary way that for any draft, L is proportional to $\sqrt{D}$ (D being the roll diameter). This means that for equal drafts the contact length between 20-in. rolls will be about three times as much as with 2-in. rolls, because

$$\sqrt{20} : \sqrt{2} = 4.48 : 1.415 = 3.16$$

For this reason one can reduce metal by rolling three times as much with 2-in. rolls as with 20-in. rolls before the limiting L/t ratio is reached.

In practice, this proportion may be substantially modified by strip tension, roll face friction, and hardness of the material, all of which may vary considerably from one case to another. Strip tension by hold-back and take-up reels brings the strip part way toward yielding, so that the necessary compression force exerted by the rolls is correspondingly reduced, the length of contact is reduced and L/t lowered. Hence, one can give strip more reduction before a limiting L/t is reached than if tension were absent.

As regards friction: Efficient lubrication permits the mill to roll thinner strip than would be possible otherwise. Only through the combination of powerful interstand tensions and of palm oil lubrication can tin-plate be rolled thinner than 0.01 in. in tandem mills with 20 to 22-in. work rolls. Both factors depress the actual resistance to deformation (apparent yield strength) by

bringing it nearer to the "natural" value which is independent of the L/t ratio.

Finally, the limiting amount of reduction will be reached sooner with a hard than with a soft metal, because the apparent yield strength will increase faster. If other possibilities are not available (such as a mill with thinner rolls) and if the tension cannot be safely increased or lubrication improved, all that remains is to re-anneal the strip.

Practical Examples — Temper rolling of light-gage steel strip is carried out dry and the friction between rolls and strip is high. Since the strip may be as thin as 0.008 in. and the rolls are large (16 to 18 in.) the ratio L/t is large and so is the apparent resistance to deformation. We should expect, therefore, that only an extremely small reduction could be obtained. This is true; it is often impossible to get even 1% reduction in one pass on the dead soft strip; if a tandem mill is not available, two passes may be required to reduce the strip by 1 to 2%.

In contrast, some performance figures of a Rohn mill with 0.16 to 0.30-in. work rolls, described by Schumacher, may be of interest. This miniature mill is used in the Bell Telephone Laboratories for making Permalloy foil 0.0001 in. thick. With this hard material up to 12 passes are needed when one starts with 0.002-in. strip and uses conventional lubrication. However, when the "thick" strip is first electroplated with a porous copper layer and later soaked in oil, the reduction to final thickness is in a single pass! (The copper plating is eventually dissolved.)

This represents probably the most efficient means of reducing friction in cold rolling ever applied, and it is to be regretted that it is too costly for more general use.

It is quite plain that the average roll pressure on the contact area of the Rohn mill must have been but little more than the natural yield strength of the hard rolled Permalloy, by virtue of the combined action of extremely low friction and tension on the limiting L/t ratio.

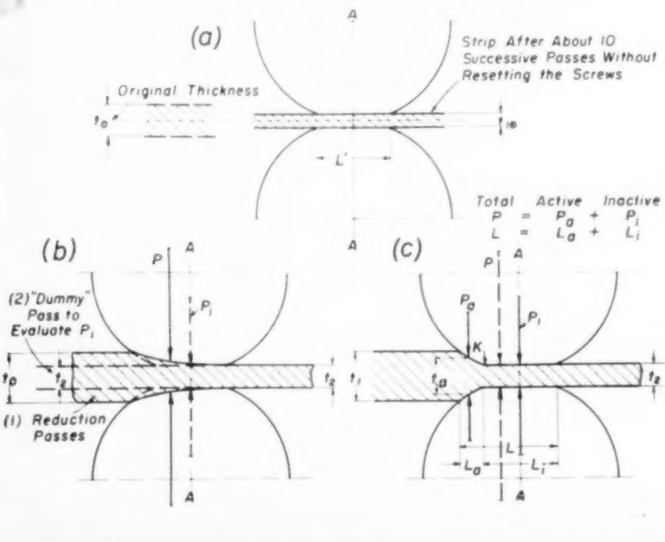
The Inactive or Elastic Roll Pressure — When a rolling mill is set for, say, 30% reduction in a particular pass, the strip will get considerably thinner if it is passed through several times without even touching the screws. But the reduction in each consecutive pass will be only a fraction of the preceding one; after eight to ten passes the drafts will fall to zero.

Mathematical theories of rolling imply that if the draft (reduction) is nil, the roll pressure should also be nil. This is not even approximately true. Roll pressure on the second pass may have fallen by only half its original value at first pass, and it finally becomes constant, no matter how many more passes are added. The mill ceased to reduce the thickness when the apparent yield strength of the work hardened strip became just equal to the average roll pressure. No plastic deformation can occur thereafter unless the roll pressure is increased or the apparent yield strength of the strip reduced by one of the methods enumerated earlier.

The condition of rolling without causing reduction is sketched in Fig. 5(a). Since there is no permanent deformation, the useful torque and power are zero, so that theoretically the mill should not take energy from the supply system. It obviously does, to compensate for losses in the mill's transmission.

The maximum roll pressure that can be supported by the rolled strip without being reduced in thickness may be called "inactive" or "elastic" pressure, P_i, which does not contribute

Fig. 5 — Schematic Representation of the Contact Arc in Rolling. (a) Condition established after many passes at a constant screw-down setting. (b) Method of evaluation of the inactive roll pressure. (c) Active and inactive parts of the contact arc



directly toward useful deformation, and which can be approximately evaluated thus:

A strip or sheet is first put through the rolls under such a low screw pressure as to cause no reduction. This is repeated several times, with the screw pressure increased stepwise before each group of passes. At some screw-down setting a small reduction of thickness will be observable, thus indicating that the inactive pressure P_i has just been exceeded. The value of P_i determined in this way is representative for one set of conditions only — that is, for a given L/t, coefficient of friction and natural yield strength. (This P_i should be measured on material which has already been reduced somewhat; see Fig. 5-b.) It is clear that for equal materials and initial and final strip thicknesses, the values of the inactive roll pressure P_i must rise when roll diameter is increased.

Power Consumption — It remains to consider the question, "Why is power consumption per ton unaffected by roll size?" Since P_i is the inactive component of the total roll pressure P, the difference $P-P_i$ must represent the "active" roll pressure P_a which actually deforms the metal. The inactive pressure P_i is distributed around the vertical plane of symmetry A, A (Fig. 5), but the active pressure $P_a = P-P_i$ acts largely near the entry of the roll gap, where most of the deformation occurs. One can consider the whole contact area as consisting of two separate parts, L_a and L_i; Fig. 5(c). The first, L_a, represents the zone of plastic deformation, whereas the other, L_i, is a purely elastic region in which the rolls roll over the strip like an automobile tire on the road. In reality, the sharp corner K of Fig. 5(c) is rounded, and the transition between L_a and L_i is smooth, but this does not affect the general concept.

For any coefficient of friction between tools (compression plates, anvils, rolls) and the worked metal, the work of deformation per unit volume increases as the L/t or D/H ratio rises. Some comparative calculations carried out by the writer indicate that with a 0.003-in. draft on a 0.009-in. strip, the average value of the L/t ratio in the last stand of a tin-plate mill with 22-in. rolls must be of the order of 65 to 70. When the same pass is done in a mill with 2-in. rolls the above ratio is only 13 to 15. This would suggest that the first mill should consume a lot more power per rolled ton than the 2-in. Sendzimir mill.

Such a conclusion is not correct because it is not this over-all ratio L/t that matters but the ratio between L_a and t_a of Fig. 5(c). The value L/t is always greater than L_a/t_a — often up to several times. In the example just quoted, L_a/t_a is only about 7 in the small-roll mill, and around 11 in the 20-in. one, so the actual work of deformation is not greatly different.

In Fig. 6, which is now self-explanatory, the effect of roll diameter on the active and inactive contact lengths is shown in an exaggerated manner.

Conclusions — With a given metal, coefficient of roll face friction, and strip tension, rolling without reannealing can be continued until a limiting ratio between contact length and strip thickness is reached. Since, for equal drafts, the contact length decreases when roll diameter is reduced, the final thickness to which a strip can be rolled is also reduced in approximately the same proportion. This is why small rolls can roll to thinner gages.

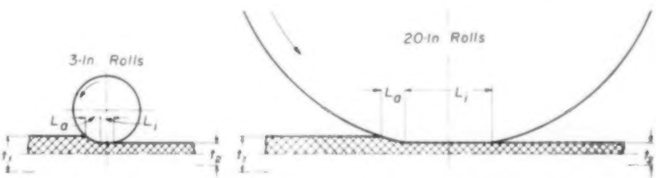


Fig. 6 — Effect of Roll Diameter on Active (L_a) and Inactive (L_i) Contact Lengths for Equal Reductions. L_a is little affected by roll size

The contact area can be regarded as consisting of first, an active part near the entry where plastic compression takes place, and second, an inactive portion where deformation is elastic.

By increasing the roll diameter, the inactive, elastic length may be considerably increased, but the active length is affected very little. Consequently, the active length-to-thickness ratio determining the work of deformation is virtually independent of roll diameter. Hence, the power required for rolling depends on the material and the reduction but not on the type of mill.

Atomic Energy for Combating Cancer

RADIOACTIVE ISOTOPES have proved extremely potent tools for cancer research — that is to say, in the search for basic facts bearing on the nature of abnormal growth processes and their diagnosis and treatment. The work is greatly simplified if one factor can be clearly identified throughout the reactions involved. With "tagged" atoms of radioisotopes such identification can be made without alteration of the character or course of the reaction, since the chemical properties of a radio-isotope are identical with those of the normal element, and the radiations themselves can be detected in amounts so small as not to influence the reaction.

The means of detection of radioactive atoms and their approximate quantitative measurements are relatively simple — the darkening of photographic emulsions, the ionization of air or other gases as measured by the electroscope or the Geiger-Müller tube and counter, the emission of photons from such substances as anthracene and their pickup by photomultiplier tubes. Each of these methods has certain specific advantages for particular situations and improvements are being rapidly made in the instrumentation.

The ready availability of radioactive isotopes came about with the development of the chain-reacting pile. [Normal atoms when exposed to the intense activity within such a pile are artificially excited.] From the Atomic Energy Commission's establishment at Oak Ridge thousands of shipments are made annually to research workers at well below production costs.

The chemical elements are rarely important, as such, in biologic problems. Rather, compounds are of major significance. Simple compounds can be synthesized and the more complex compounds produced by biosynthesis. Thus, digitalis with radioactive carbon incorporated into the molecule is formed when radioactive carbon in carbonate or carbon dioxide is provided to the foxglove plant. Long lists of such complex substances are now available.

In cancer research C_{14} is probably the most widely useful radioactive isotope, largely because carbon is such a key substance in almost all biological systems. Carbon 14 gives off a relatively poorly penetrating beta particle [electron]. Its half-life is long, 5900 years. Its presence can be readily determined by the techniques of radio-autography.

Phosphorus 32 has likewise proved very useful in cancer research. Its beta particle is much more penetrating than that of C_{14}, and its half-life much shorter, 14 days. Since phosphorus is an important constituent of nucleic acid compounds, it has been of great use in studying the synthesis of these key substances in the cell and their relation to problems of cell growth and cell division. It has also proved very useful in the localization of tumors of the brain or of the breast by administering radioactive sodium phosphate, which concentrates in the rapidly growing tumor tissue. In the diagnosis of certain types of thyroid cancers, radioactive iodine (giving off both beta and gamma radiations) has also proved of great value.

X-rays, surgery, and radium have been the basic methods for treatment of cancer. Both X-rays and radium affected all cells within the path of their radiations, and the extent of their damage to tumor tissue depended on the amount of radiation that could be delivered without too great damage to surrounding normal tissues. Availability of radioactive isotopes brought significant changes into this situation. First, certain of the isotopes may be selectively taken up directly by tumor tissue, so that their radiations are concentrated in or near the tumor, with little effect on normal tissues. Radio-iodine, selectively absorbed by some thyroid cancers, is a case in point. Another example is radio-phosphorus, which concentrates in rapidly growing cells in the tissues, and is important in the treatment of leukemia.

Such isotopes can be administered easily, and exert their effects until excreted or their radioactivity has decayed.

Gold 198, which emits both beta and gamma and has a half-life of three days, is injected in colloidal form directly into the tumor where it slows down the growth of the tumor cells and also slows down the formation of excess fluid by the normal lining cells.

One isotope of particular interest is Co_{60} (with half-life of 5.3 years) used as a substitute for radium either for direct implantation into tumors or as a powerful external source of radiation very similar to that of radium. Cobalt can be made radioactive in the atomic pile much more cheaply than radium can be mined and isolated. It will not do the job any better than radium will, but it will do it much more cheaply.

While a number of isotopes have already proved useful in cancer therapy, they have as a whole proved disappointing. However, the possibilities still exist. There are still many isotopes whose value has not yet been explored. For this purpose, and to study the effect of isotopes of short life which cannot be transported very far from the pile which produces them, the Atomic Energy Commission has established three cancer hospitals, one at Oak Ridge, one at Brookhaven, and the third at Argonne National Laboratory.

*From an address by Shields Warren, director of division of biology and medicine, United States Atomic Energy Commission, before the American Assoc. for the Advancement of Science, Dec. 28, 1951.

By Walter L. Finlay and Milton B. Vordahl, Rem-Cru Titanium, Inc., Midland, Pennsylvania
Photomicrographs by John Resketo

The Titanium Alloys Today

After much preliminary fanfare about the "wonder" and the "Cinderella" metal, titanium is beginning to show some solid substance. Current production is understood to be at a rate in the neighborhood of four tons of titanium sponge per day. And, within the past year, a number of titanium-base alloys have come on the market having strengths more than double that of the previously available, commercially pure titanium.

All of these high-strength titanium alloys possess a basically similar metallurgical structure. This is rather unusual for a structural metal, and the following paragraphs outline some of its characteristics, as well as affording an over-all view of today's titanium alloys.

Unalloyed titanium is allotropic, being hexagonal-close-packed alpha below 885° C. (1615° F.) and body-centered-cubic beta above that temperature. All high-strength titanium-base alloys so far offered commercially are mixtures of alpha and beta titanium, because all contain medium additions of iron, chromium or manganese, and each of these elements stabilizes some of the beta down to below room temperature. The result is a mixture of alpha and beta titanium which is modified but not basically changed by the addition of alpha stabilizers such as aluminum, carbon, oxygen and nitrogen.

The partnership of beta with alpha has at least three important advantages. First, the material is strengthened over the entire normal service temperature range (up to about 800° F.). Second, the forces required to hot work the material are substantially decreased. And third, despite an increase in strength at service temperatures, the bend ductility may even increase with the introduction of beta into the microstructure.

Phase Transformations — No extensive work has been reported on the crystallographic mechanism whereby alpha and beta titanium transform into each other. However, a number of investigators have established that a marked similarity exists between titanium and its Group IV-A neighbor, zirconium. The high-temperature structure of both is body-centered-cubic and both transform to the hexagonal-close-packed structure at almost the same temperature (in the neighborhood of 865° C. for zirconium and 885° C. for titanium).

Hardening Mechanism — The interpretation of the beta → alpha transformation is important because it is believed that "lattice coherency" is a significant factor in affecting the properties. The investigation by Mehl, Barrett and their collaborators of the Widmanstätten structure established that when, in the solid state, one phase formed from another, the tendency was to follow the path of least resistance, that is, the least amount of energy possible was expended to form the interface between the daughter phase and the matrix. Thus, the daughter phase forms with such an orientation to the matrix that the facing atomic planes have very similar patterns and spacings of constituent atoms. It appears that these matching planes in "pure" titanium are the dodecahedral {110} planes of the beta and the basal {0001} planes of the alpha.

However, in alloyed titanium the daughter phase has somewhat different spacings from those of the matrix. (This is also true of those precipitates that are responsible for age hardening in alloys.) Both lattices are therefore strained to maintain coherency; Mehl and Jetter ascribed a major portion of precipitation hardening to this lattice coherency strain, so that overaging is the breaking away of the two phases from coherency.

Figure 1 shows a Debye-Scherrer pattern of a rotated wire specimen of a typical alpha-beta alloy, RC-130-A (a binary 7% manganese titanium alloy). The pronounced asterism in this photogram is indicative of the lattice strain ascribable to coherency. It is evident from the nature of the mechanism involved that this type of strengthening should be termed "transformation hardening" and not "precipitation hardening".

Crystallographic Mechanism — Widmanstätten figures are prime pieces of evidence of the crystallographic nature of the mecha-

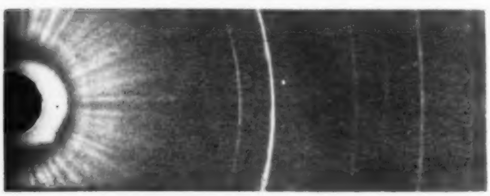
nisms causing rise to them. An example is shown in Fig. 2, the microstructure of a specimen of commercially pure titanium rapidly quenched from an all-beta temperature. The angular geometrical pattern typifies the Widmanstätten figure and reflects the fact that the alpha phase was formed on a single family of planes in each original beta grain.

The directions of the traces of the alpha platelets in several beta grains in the Fig. 2 specimen were measured and a maximum of six directions was found in a single grain. In a cubic crystal, such as a single grain of beta titanium, formation of a second phase on {100} planes would give a maximum of three directions; on {111} planes, a maximum of four directions; and on {110} planes, a maximum of six directions. That the dodecahedral {110} planes of beta titanium act as the templets for the formation of the alpha phase is buttressed by Burger's investigation of the zirconium transformation.

He obtained X-ray evidence that, in zirconium, the hexagonal phase forms with its basal {0001} planes parallel to dodecahedral {110} planes of the body-centered phase with one of the hexagonal axes [1120] parallel to one of the 110 directions in the (110) plane. Presumably, the same relationships occur between alpha and beta titanium.

Presumably also the transformation occurs by the shearing of atomic planes with respect to each other, accompanied by slight changes in atomic spacings within the planes, that is, a martensitic shear reaction. Some evidence for this type of transformation in titanium was adduced by Duwez, who reported that the transformation temperature of titanium cannot be depressed below the equilibrium transformation temperature by more than 35° C., even by quenching rates as high as 15,000° C. per sec.

Fig. 1 — Photogram of 7% Mn-Ti Wire Rotated in X-Ray Beam. Asterism indicates strain ascribable to "lattice coherency"



It should not be inferred from the foregoing that all titanium transformations are martensitic shear in mechanism. At sufficiently slow cooling rates, the transformation takes place by nucleation and growth. The crystallographic relationship between matrix and daughter phase can nevertheless still be maintained, since it is probable that the nucleus forms by the martensitic shear mechanism and thereafter grows by atom-by-atom accretion, just as a recrystallized grain grows into a strained region.

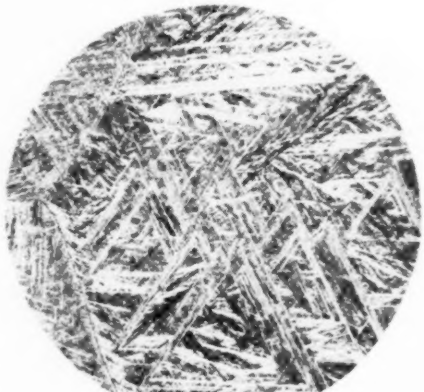


Fig. 2 — Widmanstätten Figures in Commercially Pure Titanium After Quenching From All-Beta Microstructure

TITANIUM-RICH PHASE DIAGRAMS

Of the several types of possible titanium-rich equilibria three types are prominent. These are:

Fig. 3A. Eutectoid; for example, Ti-Fe, Ti-Cr, Ti-Cu, Ti-Ni.
Fig. 3B. Peritectoid; for example, Ti-C, Ti-O, Ti-N, Ti-Al.
Fig. 3C. Beta isomorphous; for example, Ti-Mn, Ti-Mo.

A well-known example of the eutectoid is the iron-carbon diagram. Analogous importance in titanium-base alloys appears to be denied it; the resemblance is only a superficial one. The basic virtue of the iron-carbon system is the extraordinarily great solubility of the interstitial solute, carbon, in gamma (relative to its spare solubility in alpha iron), since face-centered gamma has larger volume interstices than body-centered alpha iron.

Unfortunately the situation is reversed in titanium, since the low-temperature hexagonal-close-packed phase (alpha) has larger interstices than the high-temperature body-centered phase, and a correspondingly greater solubility for carbon, oxygen and nitrogen. Associated with this greater solubility is their stabilizing action on the alpha phase and the formation of peritectoid rather than eutectoid systems.

The beta isomorphous phase diagram (Fig. 3C) is currently the one which forms the common reference frame for all commercial titanium-base alloys, since the eutectoid reaction in the iron- and chromium-titanium systems is a rather sluggish one.

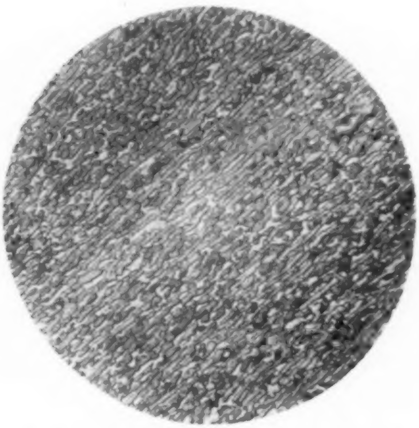


Fig. 4 — Typical Alpha-Beta Structure of Alloy Rolled at a Temperature Where Both Are Stable. 600×. Kroll's reagent (1½% HF in H_2O). Beta is clear, alpha is gray

The titanium-base alloys so far placed on the market have the following nominal compositions:

Ti – 7 Mn
Ti – 4 Mn – 4 Al
Ti – 5 Cr – 3 Al – 0.6 C
Ti – 2.5 Cr – 1 Fe – (<0.3 N or O)

Each can be considered with reference to the beta isomorphous diagram (the lower left-hand corner of Fig. 3C).

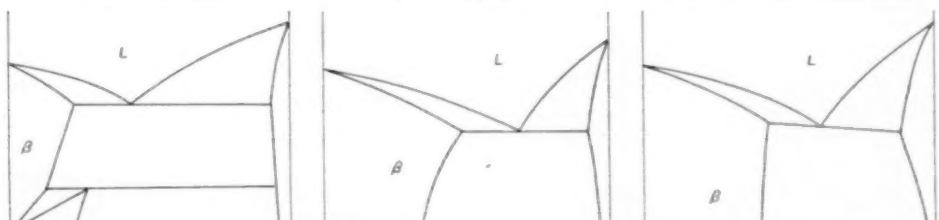
Alpha-Beta Alloys — A salient feature of the beta isomorphous alloys is a metallurgical structure which is unusual — a mixture of two strong, ductile and major constituents. A typical photograph is shown in Fig. 4 at 600 diameters. It consists of very fine, intimately interspersed, generally globular particles of alpha and beta titanium.

Aluminum has a greater solubility in alpha than in beta. It therefore presumably partitions itself with a preponderance in the alpha phase. In the Ti – 7 Mn alloy, for example, the alpha might contain less than 1% manganese, whereas the beta might contain as much as 12% manganese. However, if an alloying element is added to a binary alpha-beta alloy which stabilizes alpha, it tends to partition itself with a preponderance in the alpha phase. Thus by a judicious selection of alloying elements the metallurgist can strengthen the alpha and beta constituents separately.

In the beta-stabilized Ti – 7 Mn alloy, the beta phase is body-centered-cubic and has

Fig. 3 — Three Predominant Types of Terminal Equilibria

Fig. 3A — Eutectoid   Fig. 3B — Peritectoid   Fig. 3C — Beta Isomorphous



Titanium Alloys Today

an appreciably greater number of slip systems than the hexagonal alpha phase; such a beta-stabilized binary has excellent bend ductility combined with high strength and would therefore be suitable for rolling and fabrication as sheet.

When an alpha stabilizer such as aluminum is added to an alpha-beta alloy it strengthens the alpha constituent. This is done at some expense to bend ductility, but the contribution which a strengthened alpha makes to hot strength is very much worthwhile in improving the creep properties.

This is shown in Fig. 5 and 6, and is especially evident at temperatures above 600° F. These graphs show the elevated temperature strengths of two titanium-base alloys: *(a)* the binary 7% manganese alloy RC-130-A with a strong beta and a ductile alpha constituent and therefore with the high strength and good bend ductility required in a sheet alloy, and *(b)* the ternary 4% manganese, 4% aluminum alloy RC-130-B with both a strong beta and a strong alpha constituent and therefore particularly suited for forged parts requiring high hot strength.

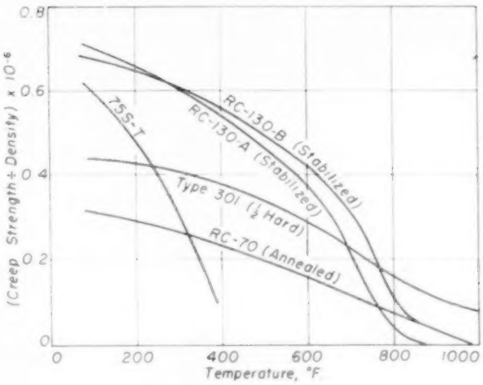


Fig. 6 — Data of Fig. 5 Recomputed on Strength-Weight Basis. Density is in lb. per cu.in.

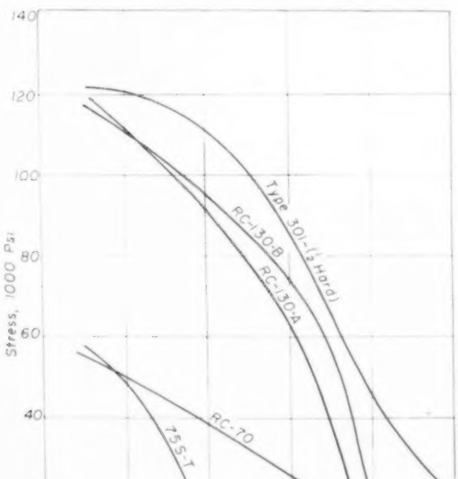


Fig. 5 — Stress for Secondary Creep Rate of 10^{-4}% per Hr. of Various Materials

Figure 6 shows that at room temperature both RC-130-A and RC-130-B have about the same strength; at 600° F., however, there is a difference of 11,000 psi. in favor of the alpha-strengthened RC-130-B; and at 700° F. this has increased to 18,000 psi.

Figure 6 emphasizes the importance of density. The titanium alloys are seen to be superior to the others, including half-hard stainless, at temperatures up to 750° F.

HEAT TREATMENT OF ALPHA-BETA ALLOYS

In our experience, processing schedules involving deformation in the two-phase field and producing the fine dispersion of alpha and beta shown in Fig. 4 develop good combinations of strength and ductility.

In the as-rolled or as-forged condition, there is usually a considerable amount of coherency hardening. This may make the material somewhat unstable during aging at normal elevated service temperatures. Accordingly, a stabilizing anneal is suggested to reduce the amount of unstable, coherency-hardened beta. For Ti – 7 Mn, 1 hr. at 1100° F. is recommended. Because of its greater thermal stability, Ti – 4 Mn – 4 Al is stabilized by 1 hr. at 1300° F.

Such stabilization does not appreciably affect the microstructure. When quenched from higher temperatures more beta is formed and retained. At room temperature this constituent remains clear (unetched)

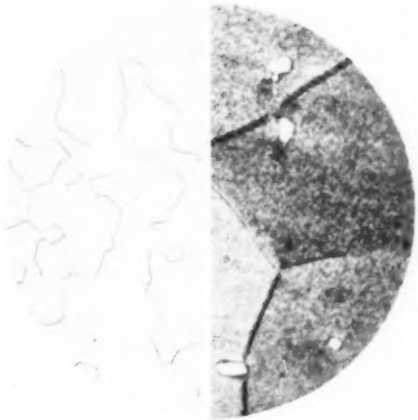


Fig. 7A (Left) — 7% Mn Alloy Water Quenched From All-Beta Region. 150×. Fig. 7B — Same after reheating 15 min. at 500° C. 600×

indefinitely and presumably little or none of it transforms to alpha. During reheating, say for 3 hr. at 500° C. (930° F.), considerable alpha is transformed from the retained beta matrix and the matrix becomes cloudy.

Rapid quenching of titanium-base alloys containing relatively large amounts of beta stabilizers, like Ti – 7 Mn, results in a completely retained beta structure as shown in Fig. 7A. This retained beta is quite unstable and will partially transform to alpha when heated for short times at slightly elevated temperatures. Figure 7B, for example, shows the alloy after heating for 15 min. at 500° C. The light-etching islands in this and in the following four photomicrographs of Fig. 8 are titanium carbides.

The sluggishness of the Ti – 7 Mn transformation is sufficiently great that isothermally transformed structures can readily be obtained with this composition. Figure 8 shows the progressive stages of isothermal transformation at 600° C. (1110° F.). Figure 9 shows the structure obtained on a Ti – 7 Mn alloy isothermally transformed for 3 hr. at 675° C. (1250° F.).

The structures shown in Fig. 8 and 9 are the result of nucleation and grain growth. Slowly cooling an alpha-beta alloy from an all-beta temperature also produces a nucleation and growth structure comprising dark-etching alpha lamellae in a matrix of light-etching beta (Fig. 11).

There is little difference between the furnace cooled structures of Ti – 7 Mn (Fig. 11) and Ti – 2 Mn except for the smaller amount of beta associated with the smaller manganese content. Rapid quenching, however, develops a marked distinction between alloys containing low and high beta-stabilizers. Figure 7A shows the retained beta in quenched Ti – 7 Mn. Ti – 5 Mn on the other hand quenches to a structure very reminiscent of steel martensite as shown in Fig. 10. We have found this distinction to be quite general for beta-stabilized titanium-base alloys, including Ti-Mn, Ti-Mo, Ti-Cr, and Ti-Fe, namely that a low content of beta

Fig. 8 — Stages in Isothermal Transformation of 7% Mn Alloy at 1110° F. 600×

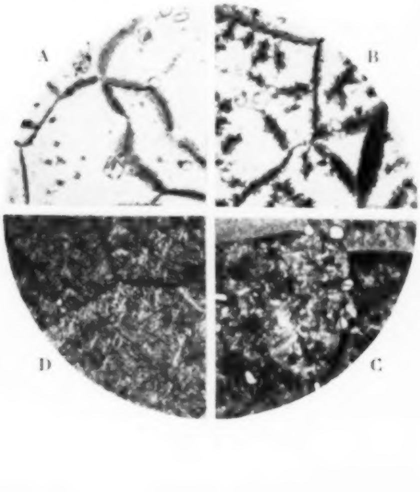


Fig. 9 (Left) — 7% Mn-Ti Alloy Transformed Isothermally 3 Hr. at 1250° F. 600×

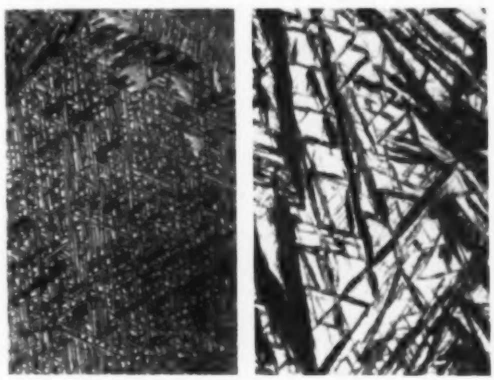


Fig. 10 (Right) — Quenched 5% Mn-Ti Alloy Resembles Martensite

Titanium Alloys Today

stabilizers will quench to martensite; high content of beta stabilizers quench to retained beta.

Cooling Rate — In order to distinguish at least in a preliminary way between structures apparently due to nucleation and growth, and the quasimartensitic structures, a series of RC-130-B specimens (4% Mn, 4% Al) was heated to an all-beta temperature and cooled at various rates.

A typical pattern of transus* lamellae due to nucleation and grain growth is seen in Fig. 11, of the specimen slowly cooled in the furnace. Slightly faster cooling rates result in somewhat finer lamellae, as would be expected from a nucleation-and-growth process. Figures 12 and 13, of specimens subjected to faster and faster cooling rates (cooled in magnesia and in still air, respectively), show finer and finer lamellae with the traces becoming more and more straight. Because of the increase in fineness of the structure, Fig. 13 is shown at four times the magnification of Fig. 11 and 12.

*Editor's Footnote — "Transus" is a term suggested by Dr. Finlay for the sloping transformation lines separating the alpha-beta from the alpha and the beta fields in the beta isomorphous diagram. It has already gained some currency among titanium metallurgists.

Fig. 11 — Slow Furnace Cool. 150×

Fig. 12 — Cooled in Magnesia. 150×

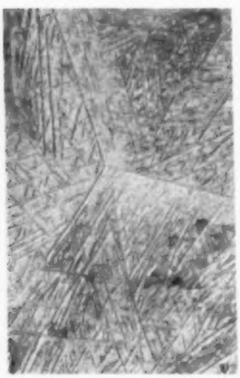


Fig. 13 — Air Cooled. 600×

Fig. 14 — Water Quenched. 600×

Fig. 11 to 14 — Variation in Microstructure of 4% Mn, 4% Al Alloy With Increasing Quenching Rates

In going from the relatively rapid cooling rate of Fig. 13 to the still more rapid quenching of Fig. 14 (quenched in cold water) a marked coarsening in structure can be observed. Whereas in Fig. 13 a typical lamella is much too short to cross an entire beta grain, a number of the larger needles in Fig. 14 appear to go right across the grain. The sudden marked coarsening with increasing quenching rate, the existence of platelet traces extending right across the beta grain, and the general appearance of Fig. 10 and 14, lead one to speculate that, in these specimens, a martensitic shear transformation superseded the nucleation and growth transformation which occurred at slower cooling rates.

In Fig. 10 and 14 there is superficial resemblance to steel martensite needles. Closer examination, however, shows an absence of the "midrib" which is a prominent feature of large needles of hypereutectoid martensite. Moreover, a fine lamellar structure can be noted in the needles in the titanium alloys. This fine structure appears to be general, since we have observed it in a wide variety of alloy compositions.

Conclusion — Although other types of titanium-base alloys will doubtless be developed, it appears likely that the alpha-beta type will continue to fill a real industrial need. There are, however, definite differences between alpha-beta alloys. Ti – 7 Mn is a representative alpha-beta alloy developed particularly for sheet; the Ti-Cr-Fe-N alloy resembles it more than the latter resembles the Ti-Cr-Al-C alloy. Ti – 4 Mn – 4 Al is a significantly different kind of alpha-beta alloy whose properties fit it for bars and forgings and where greater hot strength is required; except for its higher carbon content, the Ti-Cr-Al-C alloy appears to be the same kind of alpha-beta alloy as Ti – 4 Mn – 4 Al.

Correspondence

What Do We in the Universities Believe?

An American college is a comfortable place to teach. It offers a calm belief in the goodness of material things, "better things for better living". One feels reassured that high-grade technology will be richly rewarded — whether in engineering or medicine or law or education.

Serious questions as to the meaning of it all are scarcely tolerated, since they interfere with the daily rounds of duty and pleasure. If the work-a-day physicist is perplexed about what is "real" in the atom — perhaps only his mathematical equations have *real* existence — we consider that he is indulging his speculative powers as a sort of holiday from useful work. The atom bomb, electronics, and television are the important results of modern physics, not the theories of reality.

What if the greatest minds of all time do disagree on the meaning of the universe and man's place in it? We don't care. Let them argue. We professors are content to fight communism, go to the movies, raise our families, and hope for a Cadillac car.

If profound ideas about the moral universe, the meaning of life or the nature of man are raised, we refer the questioners to the church. We are not experts in this field. We don't pretend to have the answers. That burden is carried for us by the doctors of theology. Our greatness as a nation is in manufacturing. We are Number One in the world. Let's stick to our job!

When the people of India and China or Germany and France look at us, this is what they see: Gadgets (meaning autos, planes, TV, refrigerators, deep freeze) and the manipulations of emotions by advertising, movies, television, and newspapers, plus a system of politics which, while it smothers moral leadership, still keeps government the servant of the people. But compared to Gandhi, Marx, Stalin, America stands not for intellectual or moral leadership but for gadgets and emotions, and Europe and Asia are not impressed — they doubt that the United States can lead them anywhere.

If we were really as weak as we seem no one could complain. But we aren't. Underneath our devotion to the fictitious reality, which the physicist at the Einstein level has destroyed, the psychologist has exposed and the philosopher has shattered, lies sleeping a faith in the existence of a moral universe; in the existence of a natural law which gives to man certain inalienable rights; in a Divine Creator of which we are each a tiny spark. We really and deeply believe in these things and not in the gadgets, the emotions, and the political, economic and military arrangements of the day. But we are scarcely aware of these foundations far beneath our everyday lives. And Europeans and Asiatics would swear they don't exist in our lives!

Only when the dictatorships challenge our right to freedom of speech and freedom of worship, or deny the infinite value of the individual, do we begin to wonder where our ideas and traditions have come from. Only when man-made laws challenge man's inalienable rights do we realize whence come our belief in these rights.

Even the university is beginning to face these fundamental questions. And she is far from the last to do so. In fact, she is surprisingly conscious of the need. Watch the university for ten years — a most significant change is coming.

A Professor

Challenges Statement About Aluminum Bearings

Wembly, England

The work related in the article entitled "Improved Aluminum Bearings", by Hardy, Liddiard, Higgs and Cuthbertson and published in your October 1951 issue, represents a major advance in the technology of aluminum-base bearings.

It is very probable that the further development of this class of bearing material will depend on the use of alloys at present in use. The methods described of obtaining a structure which combines reasonably good fatigue strength with a high tin content are thus likely to be of great value.

One statement made in the article can,

however, hardly be allowed to pass unchallenged; namely, that the aluminum – 30% tin alloys "offer a combination of fatigue strength and softness hitherto unknown in bearing materials".

Copper-lead alloys with lead contents in the range 25 to 40%, which have been in widespread use for a number of years, have, in fact, very similar properties to those quoted. For example, a 65 copper – 35 lead alloy produced by powder metallurgy has a Vickers hardness of approximately 25. Since this material is always manufactured as a lining on steel, rotating load fatigue tests, comparable to those described for the aluminum-tin alloys, cannot be carried out. However, bearing performance tests and experience in the field, together with the results of tensile tests, indicate that the fatigue strength of this alloy is at least as high as that quoted for the aluminum – 30% tin alloy.

The structures of copper-lead and of the aluminum-tin alloys produced by the methods described are very similar, although it should be remembered that the volume percentage of lead in a 30% (by weight) copper-lead alloy is considerably greater than the volume percentage of tin in a 30% aluminum-tin alloy.

Theoretical arguments both for and against the aluminum-tin alloys as bearing materials can be put forward and the authors are wise to reserve judgment until bearing rig and service tests have been carried out.

P. G. Forrester
Chief Metallurgist
Glacier Metal Co., Ltd.

Rebuttal

Stoke Poges,
Buckinghamshire, England

Mr. Forrester has challenged our statement that aluminum-tin alloys containing 30% of tin offer a combination of fatigue strength and softness hitherto unknown in bearing alloys.

We believe this statement to be correct, and the evidence that Mr. Forrester has adduced respecting soft copper-lead alloys is not in our opinion sufficiently complete to warrant his contention.

We would point out that the statement in question is not based on any claim respecting the actual bearing properties of our alloys. Mr. Forrester may have regarded such claims as implicit in the statement, but we have indicated that, at the time the paper was written, practically nothing was known of the bearing properties of these particular alloys. We are thus only concerned with the two mechanical properties, softness and fatigue strength. Each of these properties has been determined experimentally. Mr. Forrester admits that the fatigue strength of massive copper-lead alloys cannot be measured directly and his comparison is based mainly on fatigue tests made on copper-lead alloys bonded to steel.

Until such time as fatigue tests have been carried out on bonded aluminum-tin alloys, a direct comparison between aluminum-tin and copper-lead is not possible. It is our intention to proceed with tests on these lines as soon as possible.

E. A. G. Liddiard
H. K. Hardy
Fulmer Research Institute, Ltd.

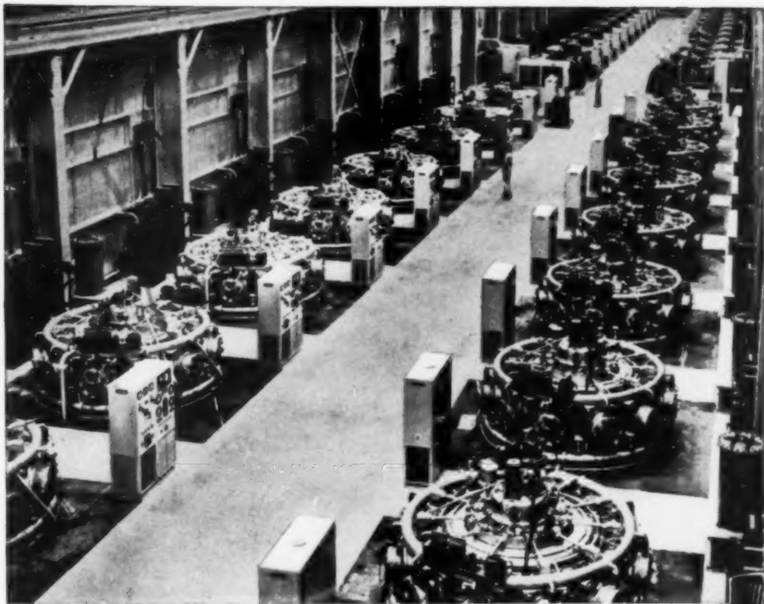
J. W. Cuthbertson
J. V. Higgs
Tin Research Institute
(Greenford, Middlesex, Eng.)

Dendritic Growth in Weld Metal

Milwaukee, Wis.

Readers of *Metal Progress* may be interested in the accompanying macrographs, one photographed at five diameters, of a weld made in five passes. Base metal was Type 316 stainless (18-12 Mo), ½-in. thick plate. A 25-20-3 Cr-Ni-Mo electrode was used to weld a joint of these plates.

The macrograph is a little unusual in that demarcation is well defined between the subsequent layers of weld metal. More



In world's largest internal combustion engine plant, operated by ALCOA, low cost power is essential for producing aluminum since every pound produced requires about 10 kilowatt hours of electrical power. *Right:* Nickel alloy cast iron crankshaft, weighing over 5,000 lbs., with gear train assembly, used in gas burning radial engine manufactured by Nordberg Mfg. Co., Milwaukee, Wisc.

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Here are some of the 120 Nordberg radial engines with vertical crankshafts of nickel cast iron which provide low cost power at the Point Comfort Reduction Works of the Aluminum Company of America, Port Lavaca, Texas.

High strength nickel alloy iron is used not only for these crankshafts, but also for the cylinder blocks. In addition, many highly stressed parts of these 11-cylinder engines are made from heat treated nickel alloy steels.

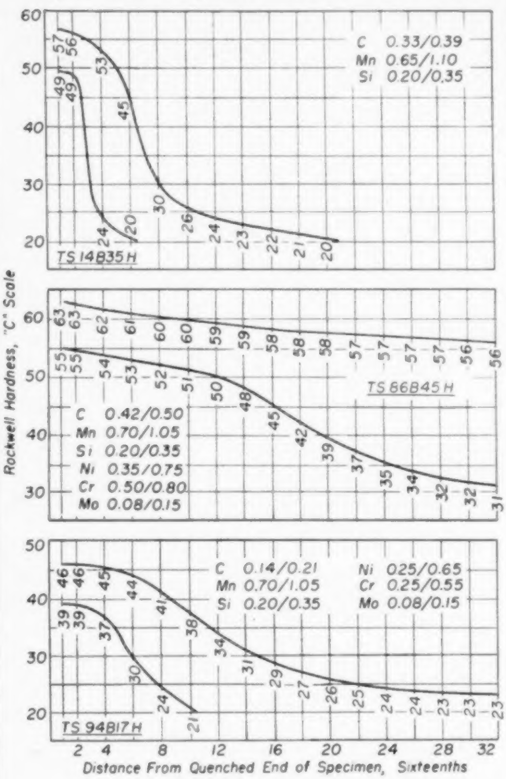
Powered by natural gas from nearby fields, these Nordberg units demonstrate how nickel alloyed irons and steels help to cut bulk and deadweight, and to render further economies by minimizing wear and corrosion.

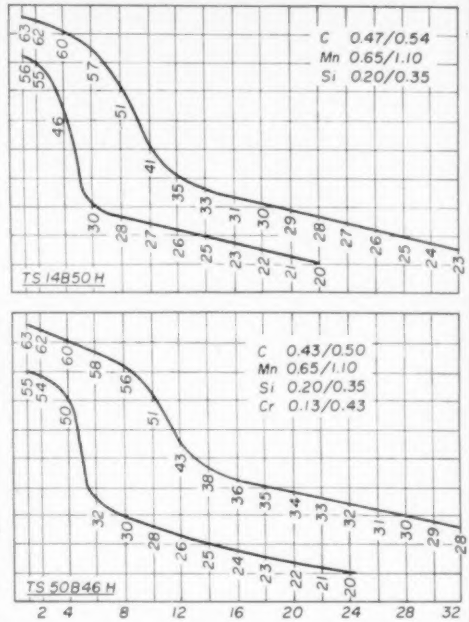
At the present time the National Production Authority limits the applications for which nickel and its alloys may be used. However, we shall continue to issue information on user experience with nickel-containing materials as we believe that dissemination of technical data and service experience can help to promote the intelligent utilization of critical materials, so essential in these times.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

Tentative Hardenability Bands for Boron Steels

Adopted Dec. 1951 by American Iron & Steel Institute





In addition to the chemical composition ranges shown on each of the Jominy diagrams, each steel can be expected to have 0.0005% minimum boron. Hardness values are adjusted to the nearest digit on the hardness scale, and are used when hardness-depth figures are selected and specified. These tentative hardenability bands apply to hot rolled alloy steels and cold finished alloy steel bars.

New Standard and Tentative Standard Alternates

Applicable to hot rolled alloy steels, cold finished alloy steel bars, and alloy steel wire

Grade	Carbon	Manganese	Silicon	Nickel	Chromium	Molybdenum	Vanadium	Notes
Standard Steels								
4118	0.18/0.23	0.70/0.90	0.20/0.35	—	0.40/0.60	0.08/0.15	—	1
5155	0.50/0.60	0.70/0.90	0.20/0.35	—	0.70/0.90	—	—	1
Steels Developed to Conserve Nickel								
TS4613	0.10/0.15	0.45/0.65	0.20/0.35	1.65/2.00	—	0.25/0.35	—	1, 2
TS4618	0.15/0.20	0.45/0.65	0.20/0.35	1.65/2.00	—	0.25/0.35	—	1, 2
Boron Steels Developed to Conserve Nickel and Molybdenum (These steels can be expected to have 0.0005% minimum boron)								
TS14B35★	0.33/0.38	0.75/1.00	0.20/0.35	—	—	—	—	1, 3
TS14B50★	0.48/0.53	0.75/1.00	0.20/0.35	—	—	—	—	1, 3
TS40B37	0.35/0.40	0.70/0.90	0.20/0.35	—	—	0.08/0.15	—	1, 3
TS43BV12	0.08/0.13	0.75/1.00	0.20/0.40	1.65/2.00	0.40/0.60	0.20/0.30	<0.03	1, 4
TS43BV14	0.10/0.15	0.45/0.65	0.20/0.35	1.65/2.00	0.40/0.60	0.08/0.15	<0.03	1, 5
TS46B12	0.10/0.15	0.45/0.65	0.20/0.35	1.65/2.00	—	0.20/0.30	—	1, 2
TS50B50	0.48/0.53	0.75/1.00	0.20/0.35	—	0.40/0.60	—	—	1, 3
TS50B60	0.55/0.65	0.75/1.00	0.20/0.35	—	0.40/0.60	—	—	1, 3
TS80B37	0.35/0.40	0.75/1.00	0.20/0.35	0.20/0.40	0.20/0.35	0.08/0.15	—	1, 3
TS81B40	0.38/0.43	0.75/1.00	0.20/0.35	0.20/0.40	0.35/0.55	0.08/0.15	—	1, 3

★See also the hardenability grade in the diagrams above.

Note 1 — The usual limitations on phosphorus, sulphur and incidental elements apply. See "Notes on Composition", *Metal Progress* data sheet for August 1951 (p. 80-B).

Note 2 — Intended for rock bit cutters and oil well drilling equipment, as alternates for the 4800 grades.

Note 3 — This steel was previously approved (July 1951) with wider ranges. See *Metal Progress* data sheet for August 1951 (p. 80-B).

Note 4 — Intended as an alternate to 3300 and 9300 grades for aircraft engine parts.

Note 5 — Intended as an alternate to 3300, 4800 and 9300 grades for heavy-duty truck parts.

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Treatment: Made of AISI 4615 steel, the rack is carburized in AEROCARB E&W at 1650°F for one hour to produce a case depth of .015–.017". It is then air cooled and the solidified salt removed by a hot water rinse. Next, the teeth *only* of the rack are hardened by *high frequency induction* heating followed by a water quench. Tempering completes treatment and teeth must meet a Rockwell hardness specification of 80-82 A.

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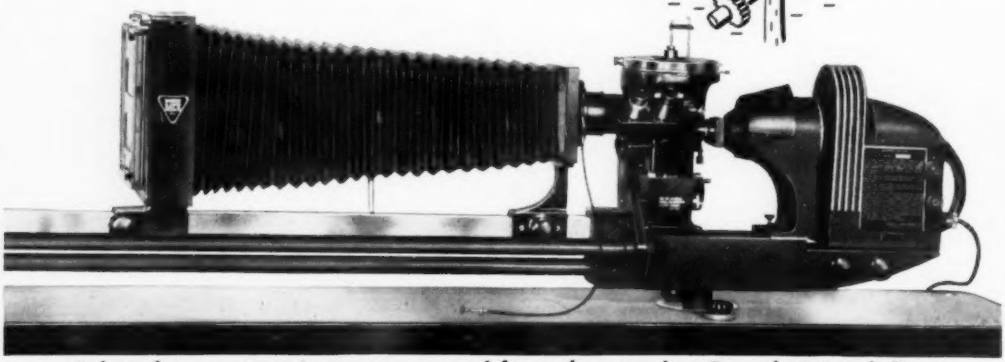

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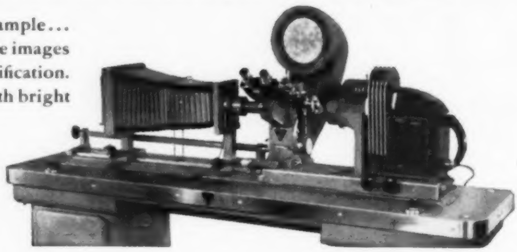

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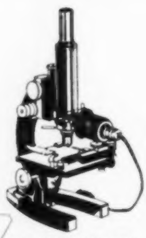

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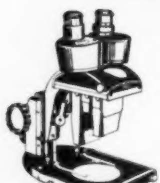

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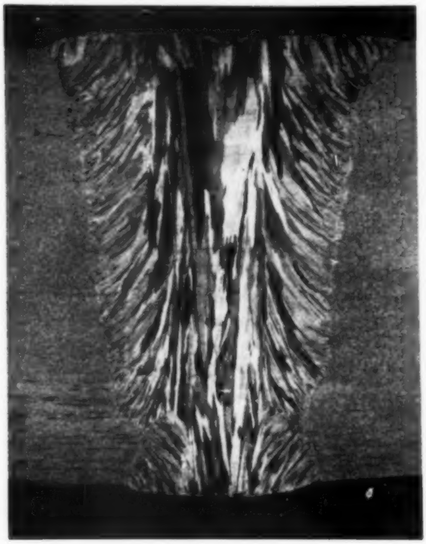
Bausch & Lomb *Metallurgical* Equipment

characteristically it shows a continuous dendritic structure, layer to layer, typical in multipass welding of austenitic metals.

It has always been of interest to me to reflect on the continuous nature of dendritic growth which originates from the first deposited layer and extends through several



subsequent deposited layers. A striking example is the second view, twice natural size, of a weld in $1\frac{1}{2}$-in. stainless plate. This weld was made in 14 layers! I have seen this occur in stainless alloy plates $2\frac{1}{4}$ in. thick welded with 22 layers.

M. A. Scheil
Director, Metallurgical Research
A. O. Smith Corp.

Phosphate Coatings

Rock Island, Ill.

Verifying the quality of phosphate coatings by U. S. Army specification 57-O-2C (salt spray) is time-consuming and requires rather expensive equipment and technically trained personnel. In an attempt to correct these features the Laboratory at Rock Island Arsenal devised the following quick test. It has provided reproducible and reliable results in production control and is so used pending its approval as a military specification for acceptance testing.

Distilled water (or other water) used as the testing medium has a pH range of 5.5 to 7.0 when tested with Nitrazine test paper. This water must be prepared at least 24 hr. prior to use to permit saturation with oxygen, although mechanical agitation or blowing with compressed air may be used to hasten the process.

Specimens of phosphated work to be tested are placed in a suitable container and are covered with the aerated water to a depth of not less than 2 in. The bath is then heated to the boiling point within 10 min. After boiling the test specimens for 15 min., they are rinsed in cold water and tested for rust with *imbibition* paper (a photographic imbibition paper sold by Eastman Kodak Co. as "Kodak Dye Transfer Paper F"). The paper is presoaked in cold water for 15 min. prior to use and is squeezed onto the surface of the specimen and allowed to remain in contact for 3 min. The paper is then examined for rust.

Any rust indication constitutes a rejection and further confirmatory tests must be made. A second failure obtained on twice the original number of test specimens constitutes a final rejection of the lot of work being tested.

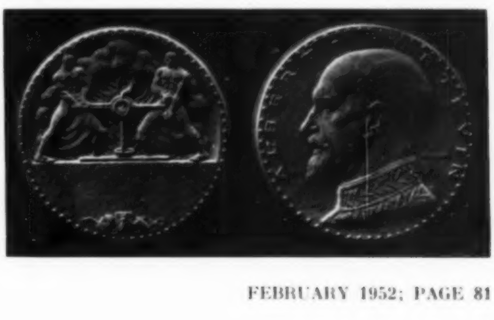
A. C. Hanson
Assistant

Portevin Medal

Paris, France

The attendant illustration shows the medal that was established last year by Prof. Albert Portevin, member of the Institute of France. It is awarded as a prize to students of the three schools at the Ecole Supérieure de Fonderie who have demonstrated best achievement in metallographic instruction and research. These prizes are supported by the residue of the subscriptions for the Academician's Sword, which was presented to Professor Portevin.

J. Laine
Director
Ecole Supérieure de Fonderie



Efficiency in the Laboratory

SANDVIKEN, SWEDEN

An industrial laboratory is essentially a production department for ideas, data, data analysis, conclusions and practical applications. There are undoubtedly many plants where the laboratory is considered an ivory tower occupied by long-haired dreamers, and there may be reasons for that view.

However, the laboratory can be operated according to organized schedules just like any production department except, possibly, for the creation of fertile ideas, although they can be produced and selected by the "morphological box" idea. All other activities can usually be segregated into repetitive and nonrepetitive, and the former can be standardized. This standardization, which makes possible the design of a production schedule and thereby enables the supervisor to follow the progress of all routine work, includes: sampling procedures, sample preparation, testing procedures and the use of standard forms for the data so that it can be transferred with ease to statistical analysis forms.

Whenever possible, we perform enough duplications of an experiment to enable us to perform some kind of statistical analysis to prevent experimental chance differences from being mistaken for real differences which are due to a cause. In some instances, we perform a simple probability calculation; that is, if we observe a certain qualitative difference in a number of experiments, it is easy to calculate the probability that chance could have given the difference the same sign so many times. It is like the chance of flipping a coin the same way that number of times.

Research projects, in our routine, are posted on a "pocket-board" with horizontal shallow pockets or grooves. A card at left gives the number (and name if desired) of each project. To the right of this is another card which indicates the next few operations to be performed. If the project remains inactive until this treatment has been completed, the card is pushed out of the vertical line as a reminder. When the operation has been completed, the next step is entered on the card. The date of completion of each operation is entered on the card.

It is vital, so as to make the idea increase the efficiency of the work, to post both the production schedule and the research tickler on the wall so that they receive the supervisor's attention. We plan now to prepare a production schedule for data analysis.

With these aids, we have in 11 months performed a rather impressive quota of work, although before the "effectivization" and standardization we seemed to have bogged down almost to a standstill. The morale and enthusiasm of all participants in these efforts have been raised to a high level as a result of the visible forward motion of the work.

Of course, there may be nothing unusual about these simple innovations, if indeed they be innovations, or of the view that a laboratory is a production unit. In any event, it would be interesting to know what others think about this.

C. A. LIEDHOLM

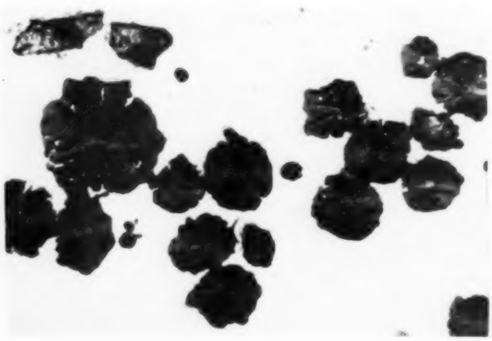
Graphite Spherulites

JAMSHEDPUR, INDIA

In a paper by A. L. De Sy entitled "Spherulite Formation in Nodular Cast Iron" (p. 798 of the June 1951 issue of *Metal Progress*) the author states that spherulitic graphite was observed in such irons only when a magnesia crucible was used for melting, whereas on repeating experiments using an alumina crucible, no such results were obtained.

Professor De Sy further states that the analysis of spherulited irons so melted showed traces of magnesium. It may be inferred from this that the spherulites might

Graphite Spherulites in Low-Phosphorus, Low-Sulphur Swedish Pig Iron, Melted in Graphite Crucible. The sample was not treated by any inoculating additions such as magnesium. Unetched, 500×



have resulted on account of the presence of magnesium or its compounds picked up from the crucible.

Some experiments were recently carried out in the National Metallurgical Laboratory by Messrs. Parthasarathi, Srikantiah and Nijhawan on cast irons rapidly quenched in a bath of melting ice from temperatures between 1600 and 1800° C. (2900 and 3300° F.). The cast irons used contained varying amounts of silicon (2 to 6%) and all the melts were made in crucibles machined out of Acheson graphite electrodes.

These experimenters observed that in all samples some of the graphite was in the nodular form and that well-formed spherulites were exhibited by samples containing more than 4% silicon. In some samples all the graphite that was precipitated was in the form of spherulites, as shown in the accompanying micrograph.

G. P. Contractor
Acting Director
National Metallurgical Laboratory

Deformation Pattern

Rochester, N. Y.

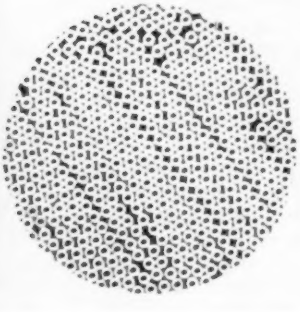
Recently, we came across a very intriguing pattern formed by the ends of a bundle of copper capillary. The 700 to 800 pieces of 0.068-in. o.d. x 0.026-in. i.d. capillary were bound with just enough tension to produce deformation bands in the form of slip lines and twins. By applying various amounts of radial pressure plus shearing forces, we found that the atomistic mechanism of slip and twinning could readily be reproduced.

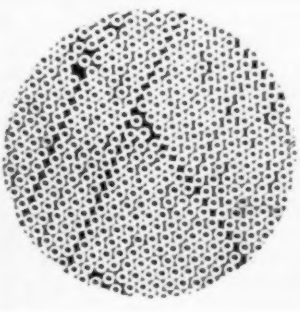
The mode of deformation obtained in the model is illustrated in these two photographs. The crystallographic pattern described by the capillary obviously conforms to the basal plane of the hexagonal close-packed system. The observer will also find "dislocations" and their relation to the origin and presence of slip lines.

The writers are well aware their model lacks uniform attractive forces between "atoms", and has a large percentage of mosaic structure. Nevertheless, a satisfactory illustration of slip and twinning processes can be accomplished with only a fraction of the effort required by the Bragg soap bubble model.

J. J. Buczynski
Metallurgist
N. J. Finsterwalder
Chief Metallurgist
Taylor Instrument Companies

Ends of 0.068-In. O.D. x 0.026-In. I.D. Copper Capillary Tubes Illustrate Dislocations, Slip Lines and Twins. 1.5 ×





Enamel Coatings

Toronto, Ont., Canada

The Ontario Research Foundation has been running a pilot operation of sponge iron and controlled density steel processes. Iron ore and coke breeze are packed in saggers or pots and passed through a continuous tunnel kiln at temperatures of 1900 to 2300° F. We have found that saggers made of a 15% Cr – 35% Ni alloy, or of Inconel, give excellent performance and good heat transfer in these processes. We did not think it possible to use such metals above 1950° F. for a sufficient length of time to justify their initial cost.

Recently we wished to operate at 2200° F., holding the material at temperature for 15 hr. Knowing of the recent work on development of high-temperature enamel coatings for jet engine exhausts, we obtained a suitable high-temperature enamel from the Ferro Enamel Co. with the idea of coating these saggers to see what protection resulted.

To get a good enameled surface, the enamel should be applied to a carefully prepared metal surface and fired under proper conditions at about 1750° F. When the coating was thus applied, excellent protection was obtained from Ferro Enamel's XS-169G.

Just as a matter of interest, we applied this enamel to the unprepared surface of saggers with a paint brush and then passed them through our kiln loaded on the normal

process cycle of 15 hr. at 2200° F. Although the resulting coat is far from meeting the standards of usual enameling practice, it does provide a remarkable amount of protection to the metal. We are now using Inconel and 15 Cr – 35 Ni saggers for service at 2200° F. for 15 hr. The total cycle is 72 hr. and the saggers are re-enameled and immediately recycled.

This practice represents the worst possible method of applying a protective enamel coating but it appears to be well worth while in saving expensive alloy since the cost of the enamel is less per gallon than the cost of ordinary paint.

We believe that this matter is worth looking into for anyone using alloy pots or saggers in carburizing or malleablizing. The Ferro Enamel Co. will specify the best enamel and the proper method of preparing the surface. Carburizing furnaces in particular are operating at about the proper firing temperature for the enamel and will probably give a far better fire than our kiln. Even the technically wrong method of painting an unprepared surface may prove worth while on such items as furnace parts which cannot be removed for surface preparation.

P. E. Cavanagh
Assistant Director
Dept. of Engineering and Metallurgy
Ontario Research Foundation

Correction

East Pittsburgh, Pa.

The data sheet, on p. 80-B of the November issue of *Metal Progress*, dealing with properties of jet engine alloys, contains a typographical error in the composition of Discaloy. The carbon content should be 0.05%, as given on the table of composition and properties that I furnished, instead of 0.5%.

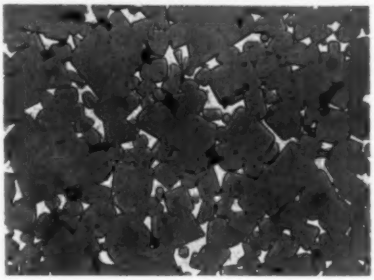
F. C. Hull
Manager, Metallurgical Section
Research Laboratories
Westinghouse Electric Corp.

Polishing Cermets

Columbus, Ohio

During the last several years there has been considerable increase in the investigation of metal-ceramic combinations as high-temperature materials. These combinations or "cermets" are fabricated by powder metallurgy techniques and result in dense, hard compacts which present difficulties in preparing polished surfaces for metallographic examinations.

The accepted method of polishing predominantly carbide and other hard metal specimens is to use diamond dust of decreasing grain size during final polishing. However, we have obtained excellent polished surfaces on TiC, TiN, and mixed carbide-base cermets using Fe_2O_3 (rouge) as a polishing agent. It has also been used successfully with Cr-Al_2O_3 cermets.



Top — "Kennametal" K-138-A; (Ti-Cb-Ta)C + 20% Co. Gray areas, TiC; light area, metal. Bottom — TiC + 20% Ni. Gray areas, TiC; light area, metal. Unetched, 1000 ×

Our procedure consists of cross-sectioning the specimen with a diamond cutoff wheel, hand polishing on silicon-carbide finishing papers of 240, 400 and 500 grit, and finally polishing with rouge on a high speed wheel (1725 r.p.m.). A few drops of a solution of 7 to 10% chromic acid containing less than 1% phosphoric acid are added occasionally to the polishing wheel. Although this solution is used as a deflocculent, it may lead to some chemical polishing, in which case no further etching is required. The two micrographs shown here are typical of the results obtained with this procedure. This method, incidentally, is used for the majority of the specimens prepared at Battelle Memorial Institute.

Clinton C. McBride
Research Associate
Ohio State University

By Joseph L. Rosenholtz and Dudley T. Smith, Department of Geology
Rensselaer Polytechnic Institute, Troy, N. Y.

Dilastrain Method for Determining Endurance Limit of Materials*

In the course of investigating the thermal characteristics of a pure calcitic marble known as Yule marble, the authors found that there were enormous differences in the coefficient of linear thermal expansion, α, depending upon the orientation of the test specimens (*American Mineralogist*, Vol. 34, 1949). This marble has a pronounced preferred grain orientation in the east-west geographic direction, a result of the stresses which produced the marble during the metamorphic process. In the thermal range from 20 to 100° C. (68 to 212° F.) α was four times as great in the east-west orientation as in either of the two other mutually perpendicular directions. It was also observed that, despite the equality of α in the north-south and vertical orientations, their respective recoveries after they were heated to 700° C. (1290° F.) were substantially different.

These observations led to the conclusion that the effects of dilation were related to the stress history of the marble in some manner which might be deduced if fundamental stress studies of the material were undertaken. Griggs (*Journal of Geology*, Vol. 44, 1936) reported that some rocks, such as limestone and marble, behaved like metals when subjected to high confining differential pressures; they displayed an elastic limit and they deformed by plastic flow when stressed above the elastic limit. It appeared desirable, therefore, to investigate the dilation characteristics of some metals before proceeding with marbles which had been deformed under large confining stresses.

A medium soft steel and extruded pure magnesium were selected for this investigation by the authors (*Journal of Applied Physics*, Vol. 21, 1950) in order to obtain a comparison of isotropic and anisotropic metals. Small cylinders of both metals were subjected to a series of progressive compressive stresses and α was determined for each cylinder. It was found that an abrupt reduction in α occurred at the initiation of yield, which is really the true yield point. The change for the steel was approximately 5% and it was somewhat larger for the magnesium. Immediately beyond the yield point stress the value of α rose abruptly and amounted to about 10% for the steel and 18% for the magnesium. These changes are clearly defined when α is plotted against the applied stress.

Similar results at the yield point of soft steel were obtained with X-ray studies by S. L. Smith and W. H. Wood (*Royal Society of London Proceedings*, Vol. 181, 1942) but the permanent lattice contraction amounted to only 0.03%. It is obvious that the changes in linear thermal expansion of a metal can be used as a precise method for locating the true yield point. On this basis the true yield point may be defined as that stress value, under conditions of static loading, which produces a permanent or irreversible dimensional change in the atomic lattice.

This discovery pointed the way to new investigations in stress analysis and the authors were joined in their further work by Prof. Joseph F. Throop of the Department of Mechanics, Rensselaer Polytechnic Institute. It is appropriate at this point to acknowledge his cooperation and to state that he was in charge of all prestressing operations which will be described presently. To begin with, a series of test specimens of an aluminum alloy was subjected to reversed axial loadings, zero mean stress, for a constant number of reversals at stresses below, near and above the known fatigue strength at 5×10^8 cycles of the alloy. All stressing in this and subsequent investigations was done in Sonntag machines. While this in no way precludes the use of other

*Patent pending.

types of fatigue testing machines, it is known that with many alloys there may be substantial variations in results, depending upon the machines employed.

The values of α were determined for the stressed bars and a characteristic α-S curve was obtained which has the same trends as an α-S curve obtained under conditions of static loading. Two additional test bars of the same alloy were then stressed, one above and one below the known endurance limit, but their respective stress values were not revealed. However, it was found possible to establish the applied stress values within less than 5% from their coefficients of thermal expansion and recoveries. The α-S curve showed an abrupt change somewhat below the known fatigue strength; this point was, in reality, at the true endurance limit.

THE DILASTRAIN METHOD

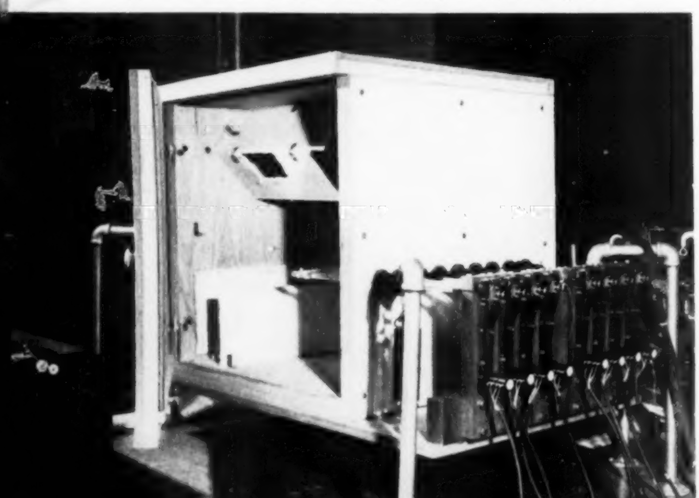
The principle of the Dilastrain method is that the coefficient of linear thermal expansion of materials, such as metals, alloys and plastics, decreases abruptly at the true endurance limit. While the fatigue strength at a particular number of stress reversals is frequently referred to as the endurance limit, the true endurance limit of a material may be appropriately defined as that stress value, under a particular character of reversed stress loading, which produces a permanent or irreversible dimensional change in the atomic lattice of the material. It is impossible by conventional testing methods to determine the true endurance limit of many alloys, even after one billion stress reversals, whereas this point is sharply defined from dilation measurements.

The Dilastrain method consists of two operations, prestressing and dilation measurement. Prestressing, which includes both understressing and overstressing, is performed on a series of eight test bars. It is preferable that the range of stress in which the endurance limit is located be established by testing a few bars to failure in the high stress range; the results so obtained, and which will later be used in constructing the S-N curve, are plotted and a relatively broad stress range can be selected which will span the endurance limit. For example, if tests of an alloy show early failure at 65,000 psi., a few additional tests at 64,000 and 63,000 psi. will establish the trend of the S-N curve. Rough extrapolation will make it evident that the endurance limit is between 63,000 psi. and, let us say, 56,000 psi. Each of the eight prepared test bars is then prestressed for the same number of cycles at 1000 psi. stress differentials in order to span the endurance limit.

The number of prestressing cycles depends upon the physical characteristics of the material. Excellent results are obtained with plastics with as few as 10,000 cycles; 50,000 cycles is adequate for aluminum alloys, brasses and bronzes; and 50,000 to 100,000 cycles induces easily measurable effects in steels. This means that the prestressing time for one set of test bars varies from 5 min. to a maximum of 8 hr., depending upon the nature of the material being studied and the speed of the testing machine.

If it is not possible to obtain the high stress fatigue strengths as outlined above, a much wider range of stress for prestressing is selected from the statically determined yield point of the material. Because the endurance limit of some metals may be above the yield point, it is imperative that a preliminary determination be made in which the stress differential is high, perhaps 5000 psi.,

Fig. 1 — Dilastrain Analyzer and Airbath. The eight multipliers may be seen extending into the airbath. Front screws are for adjusting magnifications and for setting the position of each circuit when a determination is begun



in order to span the region from well above to considerably below the yield point.

The procedure followed in all tests was to cut off the prestressed bars at just beyond the reduced section. The resulting spools were $2\frac{1}{4}$ in. long, $\frac{3}{8}$ in. in diameter at the ends and $\frac{7}{32}$ in. in diameter in the reduced section. There is no limitation with respect to these dimensions; they were convenient to use since they conformed with the shape of test bars used in Sonntag machines in which the prestressing was performed. Tests have been conducted under a variety of reversed stresses; the method is sensitive to tension, compression, torsion and bending and to combinations of such stresses.

The second part of the procedure involves the use of the Dilastrain analyzer, shown in Fig. 1. This consists of a bank of eight analyzers, each of which is a quartz dilatometer into which a cutoff prestressed spool is inserted. The expansion of the spool is transmitted to a lever arrangement which, in turn, produces a change in the inductance of one transformer of a bridge circuit by moving the transformer core. Then when a condition of unbalance is produced due to dilation, the recorder mechanism is actuated and the amount of dilation is thereby recorded. The total magnification is approximately 3500× and the sensitivity is one micro-inch. By the use of a selector switch, a record of each of the analyzers may be obtained very quickly. The free ends of all analyzers are enclosed in an airbath, the temperature of which is adjusted by a program controller. A thermocouple is inserted in each analyzer so that the temperature of each spool may be determined at the very moment its dilation is being measured.

Dilastrain is a comparison method and possesses the many advantages of such a method; the process of measurement is accelerated eight-fold and controls can be adjusted with considerable freedom. It is important, however, that the machining of each set of test specimens be performed within the same tolerance and that all machining be done under coolant. Since the bars are not stressed to failure, in fact very far from it, the surfaces need not be as carefully ground and polished as is usual in fatigue testing.

The dilation characteristics of the eight test spools are determined to best advantage from 25 to 45° C. As higher temperature ranges are employed, the dilational effect of the residual stresses and strains is gradually reduced and the normal increased dilation with increased temperature tends to mask the residual fatigue effects.

REPRESENTATIVE DATA

The values of α are quickly computed from the measured dilations and temperatures. These values are plotted against the applied fatigue stress and, as shown in Fig. 2, the true endurance limit occurs at the trough in the curve. It is seen that α rises with increased stress up to the endurance limit where an abrupt decrease occurs. Beyond the endurance limit α again increases up to a threshold value and then again decreases. With some alloys prestressed at 1000-psi. differentials, α fails regularly to the endurance limit and then rises, producing a sharp "V". It is possible to determine the endurance limit more precisely by a second set of tests in which a smaller stress differential is used. For example, it would certainly be possible to obtain a result within 500 psi. for the 1020 steel. The results for the 1020 steel are shown in Fig. 2; it had a proportional limit of 60,000 psi. and an ultimate strength of 83,000 psi. Its endurance limit in torsion determined by the Dilastrain method was 25,000 psi. The torsion-to-bending ratio is thus 0.595, which is reasonably close to the theoretical value of 0.577.

Comparable results for a 1040 cold rolled steel are as follows: Proportional limit, 52,250 psi.; ultimate strength, 114,250 psi.; endurance limit in reversed bending, 39,500 psi.; endurance limit in torsion, 22,000 psi.; ratio torsion to bending, 0.56; endurance limit in reversed bending deter-

Fig. 2 — The α-S Dilastrain Curve for a 1020 Cold Rolled Steel Subjected to 100,000 Cycles of Reversed Bending in a Sonntag Machine. Endurance limit is 42,000 psi.

mined by conventional methods, 40,000 psi.

For a 1090 annealed steel the following values were obtained: Proportional limit, 47,500 psi.; ultimate strength, 101,000 psi.; endurance limit in reversed bending, 40,500 psi.; endurance limit in torsion, 23,000 psi.; ratio torsion to bending, 0.57.

While the fatigue tests for plain carbon steels need not be carried out for excessively long periods, this is not so with many ferrous and nonferrous alloys. For example, approximately 5000 hr. of machine operation at 1725 r.p.m. are needed to test a single specimen for 5×10^8 cycles and the S-N curve continues to slope beyond that point. A second and extremely important consideration is that of scatter; this necessitates a statistical analysis of a number of tests at the same stress level so as to arrive at a representative value of the fatigue strength.

RESULTS WITH NONFERROUS ALLOYS

To determine whether scatter was appreciable in the Dilastrain method, three series of 17ST-4 duralumin bars were prestressed in reversed axial loading at zero mean stress. The test specimens were machined from several ¾-in. bars and each series was prestressed at a different time. This procedure took into consideration the possibility of minor variations in the stock and the personal equation in setting the stress loads in the testing machine. The results obtained were 11,500 psi. and two values of 11,700 psi. The approximate position of the endurance limit had been determined in a preliminary test so that the stress differential in the three comparison tests was 200 psi. and, in all cases, 50,000 cycles of reversed stress was used.

A rolled naval brass which was examined had a proportional limit of 36,500 psi. and an ultimate strength of 60,900 psi. The fatigue strength of corresponding naval brass is given as 21,000 psi. at 10^8 in the Bureau of Standards Circular No. 447, p. 105. The endurance limit of this alloy, stressed in reversed bending, was found to be 20,000 psi. at a 500-psi. differential and 100,000 cycles, and 19,800 psi. at a 200-psi. differential and 50,000 cycles.

As a final example of results, Allegheny Ludlum S-590, a chemically complex alloy, was studied in reversed bending and the endurance limit was found at 60,500 to 61,000 psi. At 2×10^8 cycles and 62,000 psi., the S-N curve for this alloy, determined by conventional methods, had a downward trend.

Because of the rapidity of obtaining the true endurance limit by the technique described above, the preparation of the usual S-N curve is greatly expedited. It is possible to eliminate several stress levels near the endurance limit which require large numbers of stress reversals. Furthermore, the curve can be evaluated more accurately with respect to scatter because the end of the curve is known definitely.

ADVANTAGES OF THE DILASTRAIN METHOD

Of special significance is the expeditious preparation of a Goodman diagram which can be completed in a matter of days. For example, an accurate diagram can be obtained from 11 points, one at zero mean stress, one each at the static yield points in tension and compression, and the others at intermediate points. Allowing two determinations at each point, one for pinpointing or checking, all Dilastrain measurements can be completed in approximately 40 hr. The time required for prestressing all test bars for such a series of tests will vary from 9 to 176 hr., depending on the physical characteristics of the material and the speed of the testing machine.

In addition to linear thermal expansion, it has been discovered that many other properties which can be measured with sufficient sensitivity respond in a manner similar to dilation but to a much lesser degree. Among those which have been or are currently being investigated are static physical, electrical and magnetic properties.

It seems entirely probable that the Dilastrain method can be adapted to a variety of stress problems. Among those now under consideration are endurance limit at high temperatures, endurance limit of a complete structural component, stress rupture, and nondestructive stress analysis to establish the remaining useful life in a structural member which has been in service. It is even possible that notch effects may be measurable by the evaluation of a small section of the test specimen. All of these and possibly additional fatigue problems will require considerable research but it seems reasonable to expect that they may be resolved in a fundamental manner.

Advertisement

ELECTROMET *Data Sheet*

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

VANADIUM...the metal that accentuates the effects of other alloying elements

Vanadium is usually added to steel or iron along with other alloying metals, such as manganese, tungsten, nickel, or chromium. It enhances the effect of these other alloys and helps to improve the physical properties of the metal. Generally it is used in quantities of less than 0.50 per cent, but even in these small amounts it is responsible for many marked improvements in the quality of iron and steel.

One of the most notable functions of vanadium is its effect in improving the dynamic properties of steel, such as fatigue and impact resistance. It also gives an inherently fine grain size to both steel and iron.

In high-speed tools, vanadium contributes wear resistance and red hardness. It is also an important alloy in many types of permanent magnet steels. These and many other types of special-purpose steels contain more than 0.50 per cent vanadium to enhance certain properties.

Dynamic Strength for Steels

The principal effect of vanadium in engineering steels is that of refining grain size. It is usually added in amounts of 0.10 to 0.25 per cent.

Fig. 1. Steels in which vanadium is an alloy have outstanding dynamic strength. That is why they are frequently used in such heavy-duty service as springs and axles in diesel locomotive trucks.

In the lower carbon ranges, vanadium steels are especially suited for carburizing and are used for such applications as hand tools, bearings, and pistons. Vanadium-bearing steels can also be nitrided effectively.

Vanadium contributes fatigue and impact resistance and also strength and ductility to spring steels. The famous chromium-vanadium (SAE 6100 series) and manganese-vanadium spring steels are outstanding examples of this use. Besides being used as springs, these steels are frequently used for axles, shafts, and other highly stressed moving engine parts.

Red Hardness in Tools

Practically all fine tool steels contain vanadium. In high-speed steels, vanadium content usually ranges from about 0.50 to 2.50 per cent, although higher percentages are sometimes used. Other alloy tool steels usually contain from 0.20 to 1.00 per cent vanadium.

Vanadium is a strong carbide-former and forms very hard and stable carbides. These vanadium-carbides are probably the main reason for the excellent wear resistance and edge-holding properties of vanadium tool steels. The persistence of the vanadium-carbides is largely responsible for the cutting qualities at red hardness of high-speed tool steels.

Adds Strength to Cast Iron

In amounts of 0.10 to 0.15 per cent, vanadium increases the strength of cast iron from 10 to 25 per cent, and adds a considerable amount of toughness. Cast iron containing vanadium is especially valuable in such applications as steam locomotive cylinders, valve and piston bushings, piston rings, and similar parts. In steam engines and diesel motors, vanadium cast iron cylinders greatly out-

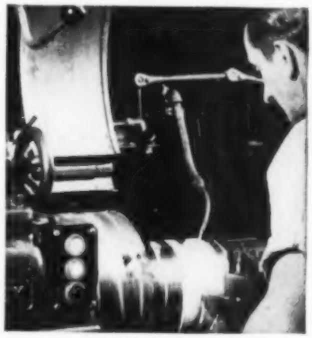


Fig. 2. Nearly all fine tool steels contain vanadium. It promotes fine grain size, high wear resistance, and greater control of hardenability. Vanadium also contributes to the red hardness of high-speed tool steels.

last those of ordinary cast iron. Chromium-vanadium cast iron rolls, containing up to 2 per cent chromium, have been used successfully in steel mills for a great many years.

Cast iron in which vanadium is the sole alloying element is used primarily in applications where temperatures are moderately high and in heavy sections requiring uniform hardness without brittleness.

ELECTROMET Vanadium Alloys

ELECTROMET produces three grades of ferrovanadium in various sizes for the production of vanadium-bearing steels and irons. Each grade has a definite range of carbon and silicon contents and is especially adapted to assure the best results in the different requirements of iron and steelmaking.

Write for a copy of the booklet, "ELECTROMET Products and Service." It contains many useful facts about the use of ferrovanadium. The booklet also describes over 50 other alloys and alloying metals produced by ELECTROMET.

The term "Electromet" is a registered trade-mark of Union Carbide and Carbon Corporation.

Personal Mention

Alfred L. Boegehold

Kent R. Van Horn

Alfred L. Boegehold, recently appointed assistant to the general manager of General Motors Corp.'s research laboratories, Detroit, graduated from Cornell University with a mechanical engineering degree in 1915. Before becoming head of the metallurgical department of the G.M. research laboratories in 1925, after five years in the department, he had been employed by Remington Arms and Ammunition Co., specializing in rifle components and cutlery, and with the Bridgeport Brass Co., specializing in electric furnace melting. He also served with the U. S. Army Ordnance, studying Browning machine gun barrel steels. He delivered the 's Campbell Memorial Lecture in 1938. In 1929 he was named winner of the J. H. Whiting prize by the American Foundrymen's Assoc., and in 1942 was awarded the J. H. Whiting Gold Medal by the same society for his work on cast iron. Mr. Boegehold was president in 1947 and a trustee from 1943 through 1946. In 1943 and again in 1948 he was an executive committee member of the Iron and Steel Institute of the American Institute of Mining and Metallurgical Engineers, and is a member of the Society of Automotive Engineers. In collaboration with others and in his own name, Mr. Boegehold has produced a long list of publications for technical societies.

Kent R. Van Horn, research metallurgist and authority on industrial X-ray, has recently been made director of research for the Aluminum Co. of America, with headquarters at the research laboratories, New Kensington, Pa. A veteran of 22 years with Alcoa, he advanced from his position of associate research director to succeed Francis C. Frary, who has retired. In his new job, Dr. Van Horn will be heading the aluminum industry's oldest and most extensive research organization. A native of Cleveland, he received his B.S. degree from Case Institute of Technology in 1926, his M.S. degree and a Sterling Research Fellowship from Yale University in 1928, and Ph.D. in 1929. He then joined Alcoa as a research metallurgist at the Cleveland division. A year later he was placed in charge of the X-ray department, and subsequently became chief of the Cleveland research division. In 1950 he was transferred to New Kensington as associate director of research. A member of many technical and research societies, Dr. Van Horn served as the youngest president the American Society for Metals ever had (1944-1945). He has been president of the American Industrial and X-ray Society, president of Alcoa's Lynite Club, and member of the American Society for Testing Materials and the American Institute of Mining and Metallurgical Engineers. He is well known for his many articles in technical publications, and as co-author of the book "Practical Metallurgy".

T. F. Fleming has been appointed general manager of the Morrison Engineering Corp., Cleveland. He will head up the company's metallurgical department. He was formerly supervisor of the heat treating department of National Screw & Manufacturing Co., Cleveland, and technical representative of the World Metallurgical Congress staff.

John N. Moore has been promoted to sales supervisor by the Hooker Electrochemical Co., Niagara Falls, N. Y. Until his recent appointment he was engaged in technical sales service for the company.

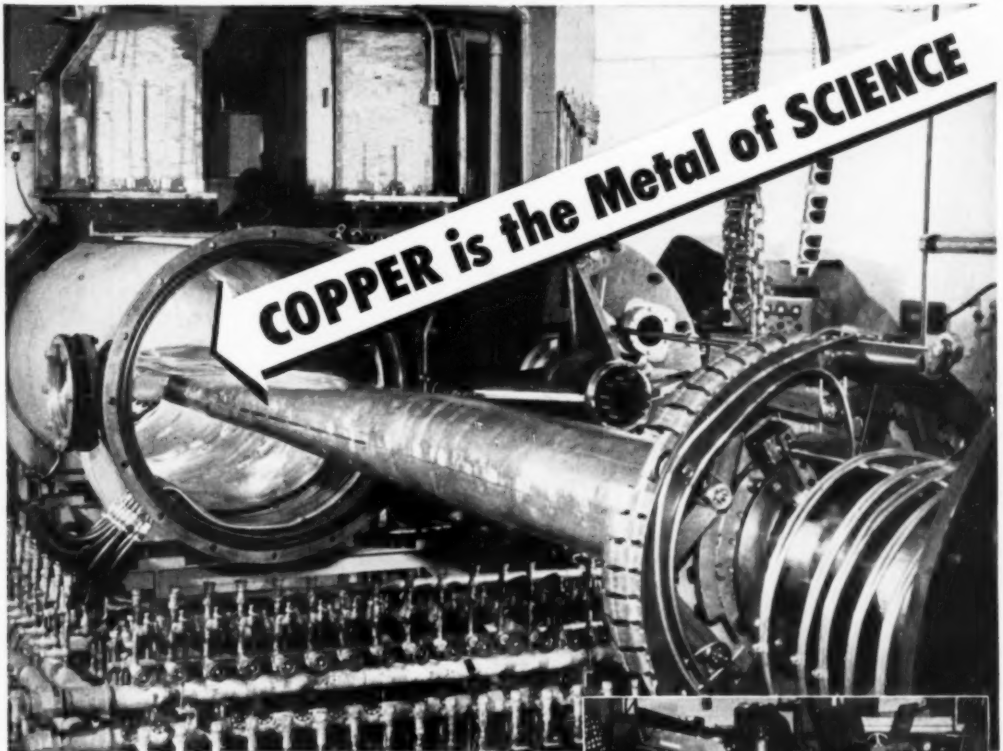
Charles F. Muench is employed in the Thomson Laboratory of General Electric Co.'s River Works, Lynn, Mass. He graduated from Lehigh Univ. in June 1951.

Raymond J. Thomas, formerly chief metallurgist at Jacobs Aircraft Engine Co., Pottstown, Pa., has been appointed chief metallurgist at the New Brunswick (N. J.) plant of the Studebaker Corp.

Vernon V. Donaldson has been promoted and reassigned as physical metallurgist for the U. S. Bureau of Mines, Ferro-Alloys Branch, Redding, Calif. He was formerly in the Bureau's Physical Metallurgy Branch, Electrodevelopment Laboratories, Albany, Ore.

Thomas H. McCunn, after completing one year on the chemical and metallurgical program, has accepted a permanent position in the works laboratory, General Electric Co., Schenectady, N. Y., and **John E. Anderson**, who graduated from the University of Wisconsin in January 1951, is currently on the training program in the works laboratory.

H. Walter Wagner, head of the research and development department, Norton Co., Worcester, Mass., has recently retired after 33 years of service.



D and D Stem being inserted in Cyclotron; made of Revere Electrolytic high-conductivity copper, hot rolled and annealed, 1/8" thick. Note also large number of bronze valves to control flow of cooling water through brass pipe.

● For many years Revere has been saying that "Copper is the metal of invention." It has high electrical and heat conductivity, excellent resistance to corrosion, is easily fabricated and formed, so that it is attractive to designers and inventors, as well as to manufacturers. Now we say it is also "The metal of science," because it is so essential to the operation of most scientific devices.

The pictures on this page illustrate some of its uses in a cyclotron, built by and for the Nuclear Physics Laboratory of the University of Washington in Seattle. The instrument was designed and constructed so far as possible by University personnel, who were completely successful in working copper into the most complicated shapes.

Revere collaborated on the project in various ways, and furnished copper bar, sheet, rod and tube to the University's high specifications. Remember that Revere will be glad to consult with you on your problems concerning copper and copper alloys, and aluminum alloys.

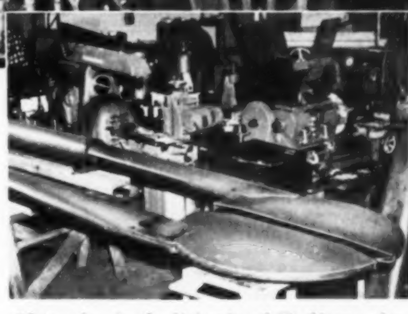


Photo taken in the University of Washington shop during fabrication of the two Ds and D Stems.

Seven miles of Revere copper bus bar were wound into great coils for the cyclotron electromagnet. The University built the winding machine itself, and wound the coils in its own shop. The special Revere bar is soft temper, free from scale, with rounded edges.

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Personals

Edward S. Christiansen, president of Christiansen Corp., Chicago, and its three subsidiaries, has been named the "Light Metals Man of the Year" by *Modern Metals* magazine, the business publication devoted exclusively to the nonferrous metals industry. The award is made annually to the individual whose contribution to the light metals field is considered the greatest.

Robert F. Mehl, director of Carnegie Institute of Technology's metals research laboratory and head of the metallurgical engineering department, will spend January in Brazil as head of a commission of the Technical Cooperative Administration under the auspices of the Department of State. Dr. Mehl, who founded the Brazilian Metallurgical Society, will study the possibilities of the development of the iron and steel industry and the profession of metallurgy in Brazil. His headquarters will be in Rio de Janeiro.

"MARVEL" HAS always had the edge

1. High Speed Steel cutting edge.

2. Tough unbreakable alloy steel body with hardened eyes.

1. & 2. Integrally welded to make a fast-cutting, long lasting composite blade that is positively unbreakable.

MARVEL High-Speed-Edge Blades assure Faster, more Accurate cutting with proven Economy and complete Safety. Only the MARVEL is a composite blade with a high speed steel cutting edge electrically welded to an exceptionally tough, strong alloy steel body.

The High-Speed-Edge does the cutting while the alloy back with hardened eyes carries the load. Blade tensions up to 300% higher than those possible with ordinary blades are recommended. This greater tension is confined to the cutting or leading edge by the location of pin holes (exclusive MARVEL design feature) and cannot be overcome by work resistance. Heavier feeds and greater speeds are practical without "run out".

With greater accuracy, higher production and lower cost per cut comes the extra dividend of Safety, for MARVEL High-Speed-Edge Hack Saw Blades are Positively Unbreakable—*they will not shatter*.

Ask your local MARVEL distributor (see classified phone book) to help you modernize your metal sawing with MARVEL High-Speed-Edge Blades. They cost no more than ordinary blades.

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MARVEL *Metal Cutting* SAWS

Better Machines—Better Blades

S. T. Jazwinski has resigned as senior staff engineer in the metallurgical department of Ford Motor Co. to join the Central Iron and Steel Co., Harrisburg, Pa., and its subsidiary, Phoenix Iron and Steel Co., as chief research metallurgist.

Eibe W. Deck has resigned his position as vice-president and plant manager of Morse Chain Co., Ithaca, N. Y., to assume the position of vice-president in charge of manufacturing at Wico Electric Co., Springfield, Mass.

J. Alfred Berger has recently been appointed acting head of the department of metallurgical engineering of the University of Pittsburgh. He has served on the University's faculty since 1940.

Robert E. Cook, field engineer with the Timken Roller Bearing Co.'s Cleveland office, has been named to the position of sales engineer of the steel and tube division of the company's Cleveland office.

Nelson W. Dempsey has been appointed assistant manager of operations of the Chicago district for U. S. Steel Co. He was formerly general superintendent of American Steel & Wire's Cuyahoga Works, Cleveland.

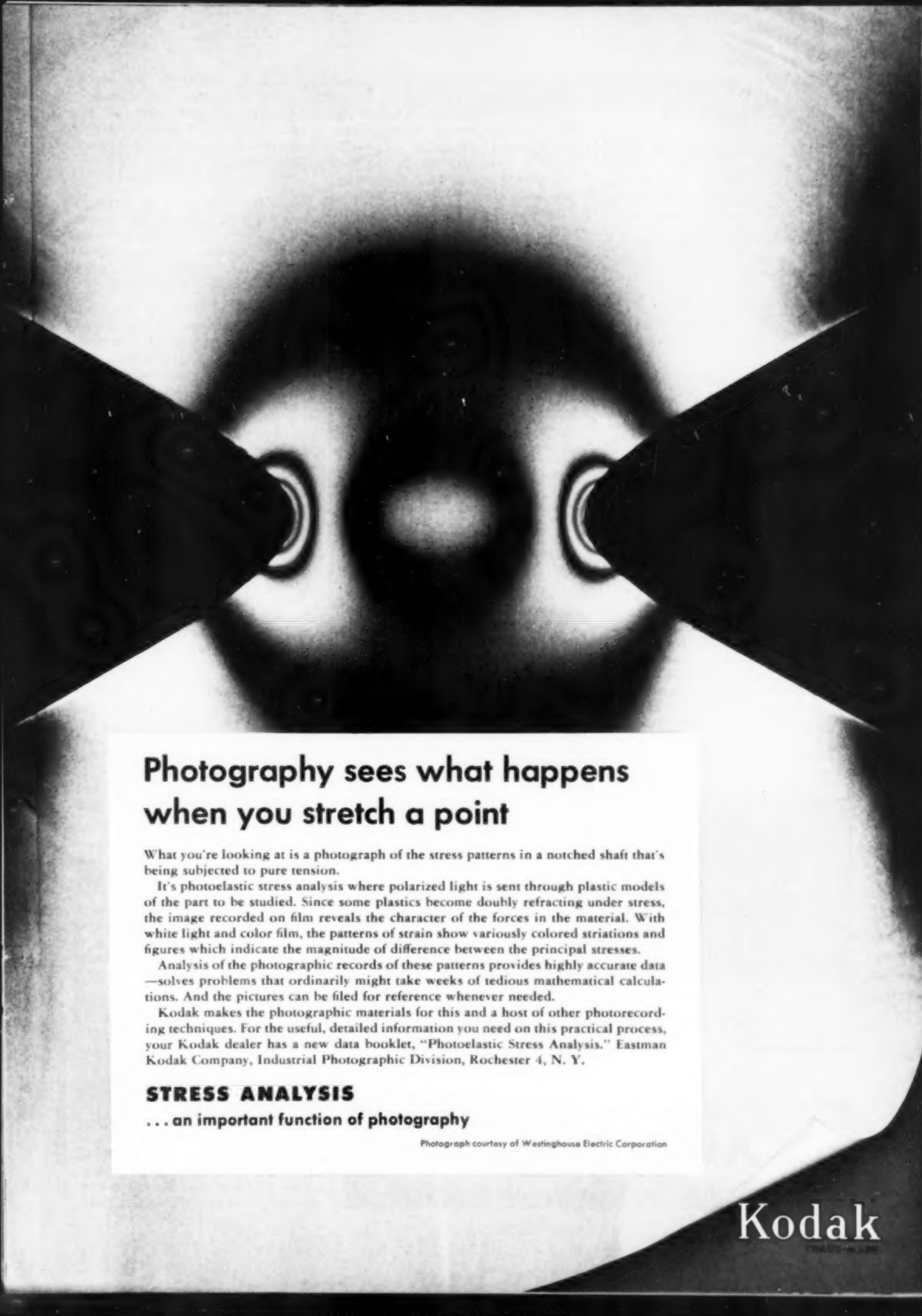
Walter G. Hoffman, formerly president of the electro-alloys division, American Brake Shoe Co., New York, has recently been appointed assistant to the vice-president of research and development for the same company.

George H. Wurster has been made eastern sales manager in charge of the recently established sales headquarters of Heppenstall Co., Hartford, Conn. He was formerly the Boston representative.

Rebecca H. (Smith) Sparling, after seven years with the company, is now design specialist heading up the metallurgy and processes group of the guided missile division, Consolidated Vultee Aircraft Corp., Pomona, Calif.

Samuel Storchheim has recently taken a position as senior metallurgical engineer with the metallurgical laboratories of Sylvania Electric Products Inc., Bayside, N. Y.

Thomas J. Moore, Jr., has been appointed general manager of Brainard Steel Division, Warren, Ohio, of Sharon Steel Corp.



Photography sees what happens
when you stretch a point
What you're looking at is a photograph of the stress patterns in a notched shaft that's being subjected to pure tension.
It's photoelastic stress analysis where polarized light is sent through plastic models of the part to be studied. Since some plastics become doubly refracting under stress, the image recorded on film reveals the character of the forces in the material. With white light and color film, the patterns of strain show variously colored striations and figures which indicate the magnitude of difference between the principal stresses.
Analysis of the photographic records of these patterns provides highly accurate data —solves problems that ordinarily might take weeks of tedious mathematical calculations. And the pictures can be filed for reference whenever needed.
Kodak makes the photographic materials for this and a host of other photorecording techniques. For the useful, detailed information you need on this practical process, your Kodak dealer has a new data booklet, "Photoelastic Stress Analysis." Eastman Kodak Company, Industrial Photographic Division, Rochester 4, N. Y.
STRESS ANALYSIS
. . . an important function of photography
Photograph courtesy of Westinghouse Electric Corporation
Kodak

Personals

R. H. English has been elected vice-president of the Alloy Casting Institute. He is chief metallurgist of the National Alloy Steel Division, Blaw-Knox Co., Pittsburgh.

Rafe Stevenson has been employed at the Continental Aviation & Engineering Corp., Detroit, as a junior metallurgist since graduating from Michigan College of Mining and Technology in June 1951.

Aaron J. Naisuler, of the National Store Fronts Co. and Northeast Aluminum in Boston, has been re-elected president of the Aluminum Extruders Council. **Leon S. Friedman**, of the National Aluminum Co., Columbus, has been elected secretary of the Council.

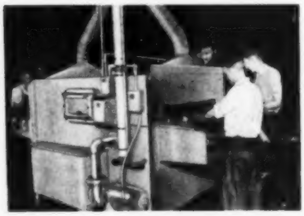
Robert D. Reiswig, who graduated from the University of Kansas last year, has been employed as a research engineer by Battelle Memorial Institute, Columbus, Ohio, since that time.

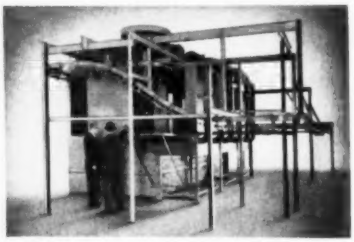
NO JOB Too Small or Too Large

Alvey-Ferguson has, for many years, provided Washing Machines to fit the varying needs of all types of metal working and other plants. These years of experience back the engineering of each specialized washer built to meet your plant's special requirements.

None Too Small—For washing metal products of various shapes and small metal parts this "Standard" Model A-F Washing Machine has been designed. It washes thoroughly, economically and efficiently.

This A-F Washer shown at right is being used by a large manufacturer to wash gummy lubricants from stampings, which must be thoroughly cleaned before assembly. If you have a cleaning or finishing problem, why not discuss it with A-F Engineers today?





None Too Large—Twenty-seven tons of water are required to fill this huge A-F Cleaning and Drying Machine to operating level. Incorporated in this 14-foot giant are many special design features. A-F Engineers are specialists in all types of "custom-built" equipment. *Write for folder —today!*

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Paul E. Chisler, chief metallurgist for the steel and wire division, Acco Products, Inc., for the past 11 years, has been elected vice-president and general manager of the Ivy H. Smith Co.'s new wire mill in Jacksonville, Fla.

Melville Morris, formerly president of Optimus Equipment Co., Matawan, N. J., has recently become president of Topper Equipment Co., Matawan. The latter company has purchased Optimus.

William R. Miller has been appointed manager of the metallurgical department of American Steel & Wire Co., Cleveland. He was previously assistant manager of the company's metallurgical department.

Edgar Landerman has recently joined the staff of the metals joining laboratory, Westinghouse Corp., East Pittsburgh, Pa., as manufacturing engineer.

R. B. Kroft has been transferred from International Nickel Co.'s Cincinnati technical section to the Detroit technical section where he will assist in the expanding defense activities of the Detroit area. **C. T. Haller** has been placed in charge of the Cincinnati technical section.

Roncisco H. Davis, after nearly 34 years of continuous federal civil service, has retired from his position of shipyard welding engineer at the Pearl Harbor Naval Shipyard, Hawaii, and after a brief interval of rest has returned to federal employment as shipyard welding engineer, at the Naval Shipyard, Long Beach, Calif.

N. C. MacPhee, former past chairman of the Ottawa Valley Chapter, has recently been appointed chief of the division of physical metallurgy, Department of Mines and Technical Surveys, Ottawa, Ont. He was formerly a metallurgist with the Mines Branch of the Department.

Herbert M. Meyer, editor for Engineering Index, Inc., New York, has been named an associate metallurgist in the metals research department at Armour Research Foundation of Illinois Institute of Technology.

Clarence H. Richards, formerly with the Allegheny Ludlum Steel Corp., Watervliet, N. Y., is presently employed as an industrial engineer by the American Steel & Wire Co., Worcester, Mass.

Desand-degraphitize castings in 10 minutes with VIRGO® MOLTEN CLEANER

UNLOADING VIRGO-CLEANED CASTINGS from continuous cleaning line.

HERE ARE THE BENEFITS!

- Longer machine tool life.
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- A cleaner, better product.

With Virgo Molten Cleaner your castings are completely free from sand and graphite before they are machined, giving you greater machine tool life. Any surface defects on castings are shown up, and you can scrap defective castings before they are machined. This same freedom from impurities insures trouble-free operation for your product when it is placed in use.

The process is simple and easy to operate—does not require close supervision. A five-minute immersion of castings in Virgo Molten Cleaner bath at 800° F. is usually enough to dissolve every trace of sand, and dissolve graphite to satisfactory depth. A water quench removes salt and leaves a protective coating on the castings. (This coating is corrosion-resistant and may be left on if castings are to be stored.) The coating is removed by a three-minute dip in dilute acid. A brief water hosing or rinse completes the job.

You can use the Virgo bath, at higher temperature, to stress relieve while desanding. By combining operations in this way, costly annealing equipment, as well as the additional operation can be eliminated.

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chose Birmingham* to serve the *Growing Southeast*

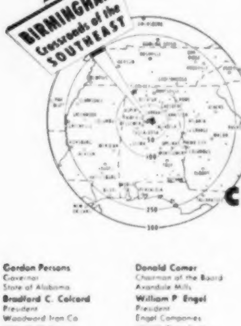
***One of Butler's 5 Large Plants**

Butler Manufacturing Company is one of the largest manufacturers of fabricated metal products. After a long study to determine the most desirable location for a plant to serve the Southeast, Butler selected Birmingham. It established recently a large plant on a 40-acre site in Birmingham's western section. This plant is now making prefabricated steel buildings, welded steel tanks and a wide variety of custom-built equipment fabricated from structural steel and steel plates.

"Our mounting sales in the Southeast made it imperative for us to have a plant to serve this growing market," said Oscar D. Nelson, president of Butler Manufacturing Company. "Our study convinced us that no city in the Southeast equals Birmingham's advantages to us for the manufacture and the distribution of our products in that section. Birmingham offered us doorstep steel supply and all accessory items that we needed, such as fittings, valves, welding rods and lumber, produced largely by local or regional enterprises. Birmingham also has a plentiful reserve of skilled labor and adequate power, water and gas. We are more than pleased with the progress of our Birmingham plant and confidently expect its growth to keep pace with the remarkable development of this great district."

* * * * *

Butler is one of many recently established industries that have found the Birmingham district an unexcelled location from which to serve the Southeast. The Committee of 100 or any of the undersigned members of the Executive Committee invite your confidential inquiries for specific data regarding Birmingham's advantages for your plant, office or warehouse.



BIRMINGHAM COMMITTEE OF 100

1914 Sixth Ave., N., Birmingham, Ala.

Executive Committee

Gordon Persons, Governor, State of Alabama
Bradford C. Colcord, President, Woodward Iron Co.
John S. Coleman, President, Birmingham Trust National Bank
Donald Comer, Chairman of the Board, Avondale Mills
William P. Engel, President, Engel Companies
W. W. French, Jr., President, Moore Handley Hardware Co.
Clarence B. Hanson, Jr., Publisher, The Birmingham News
W. H. Hoover, President, Employers Insurance Co. of Alabama
Mervyn H. Sterne, Sterne, Agee & Leach
Claude S. Lawson, President, Sloss Sheffield Steel & Iron Co.
Thomas W. Martin, Chairman of the Board, Alabama Power Co.
J. C. Persons, President, First National Bank
O. W. Schanbacher, President, Loveman, Joseph & Loeb
A. V. Wiebel, President, Tennessee Coal, Iron & Railroad Co.

Personals

E. L. AuBuchon ⊕ has resigned his position as openhearth metallurgist for Wisconsin Steel Division of the International Harvester Co. and accepted a position in the microcast division of Austenal Laboratories, Inc., Chicago, as a metallurgical engineer.

H. C. Beik ⊕ has been made district manager of the Chicago sales office of the North American Manufacturing Co.

Carl F. Floe ⊕, professor of metallurgy, has been named assistant provost at Massachusetts Institute of Technology, a new post created to handle problems connected with research and the division of industrial cooperation. He was a consultant to the Army Quartermasters Corps and defense industry during World War II.

E. F. Tibbetts ⊕ has left his position as metallurgical engineer for the Lummus Co., New York, to join the Wollaston Brass & Aluminum Foundry, North Quincy, Mass., as vice-president.

Herbert L. Klebanow ⊕, who graduated from the University of Cincinnati in June 1951, has been employed as a research engineer by Battelle Memorial Institute, Columbus, Ohio.

W. J. Leonard ⊕, formerly materials engineer, David Taylor Model Basin, Navy Yard, Washington, D. C., is now a metallurgist with the metallurgy division of Union Carbide & Carbon Chemical Co.'s Oak Ridge National Laboratory, Oak Ridge, Tenn.

Robert MacDonald ⊕, a June 1951 graduate of Carnegie Institute of Technology, has been employed by the materials laboratory of General Electric Co.'s Aircraft Gas Turbine Division, Lockland, Ohio.

Charles W. MacGregor ⊕, formerly professor of applied mechanics and head of the materials division at Massachusetts Institute of Technology, has been named vice-president in charge of engineering and scientific studies of the University of Pennsylvania. In this newly created office, Dr. MacGregor will have jurisdiction over the engineering and scientific departments of the University as well as the Towne Scientific School and the Moore School of Electrical Engineering.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Basic Stages of Deformation*

EXPERIMENTS were conducted on polycrystalline 99.98% aluminum at a variety of strain rates and temperatures. X-ray back reflection photographs were made from each specimen before extension and after various amounts of strain. The observations led to the conclusion that there are three basic mechanisms involved in plastic flow of aluminum and that each has certain distinguishing characteristics.

The first mechanism is the familiar process of slip which is associated with deformation at lower temperatures or at high strain rates at elevated temperatures. It is associated with the most drastic dissociation of grains. The substructure developed by slip consists of relatively undistorted blocks between slip planes. The evidence for this is that there is a direct correspondence between the average spacing of slip lines and the size of the substructure elements shown by X-ray examination.

Before deformation of an annealed specimen, the grains yield sharp X-ray reflection spots. After deformation, the reflections are seen as clusters of separate smaller spots centering around the position of the original large spot. Imperfection is indicated by a diffused spreading of the small spots forming the cluster. This characteristic was always found to be associated with slip. The cause of the spreading was thought to be due to the formation of very small crystallites but might have been caused by lattice distortion due to high local stresses.

The second stage or type of deformation was called the "cell mechanism". As the temperature of straining was increased, or as the rate of strain at one temperature was decreased, the slip lines became more widely spaced. At sufficiently high temperatures and low rates of strain, slip lines could no longer be detected. When this occurred, the size of the substructure units increased. This was the stage in which the cell mechanism operates. Under these conditions, the X-ray reflection spots from the individual subgrains were as sharp as the reflections from the initial grains.

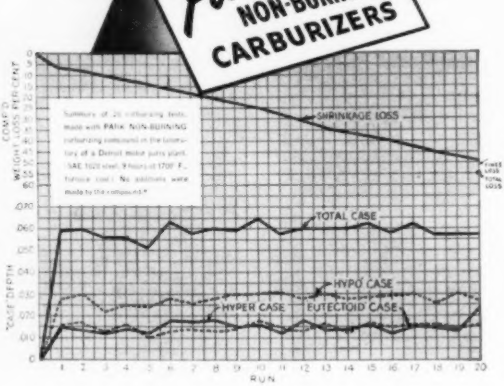
The distortion of the X-ray pattern which characterized the slip process was entirely absent during the "cell mechanism" stage. The sub-boundaries appeared to be similar to grain boundaries, varying only in that the difference in orientation of adjacent regions was small. The cell boundaries became visible on an initially polished surface. Discontinuous displacements of surface markings (such as scratches) occurred at the sub-boundaries during deformation. The change in shape of grains was presumed to occur by internal block movements. This is the "cell mechanism". (Reviewer's note: The mechanism whereby plastic flow occurs by the "cell mechanism" is not discussed and the concept of plastic flow based on such a mechanism is as yet rather vague.)

The third stage of deformation was called "boundary microflow". The size of the substructure was found to increase continuously with increasing temperature. Thus, it is reasonable to expect that at some high temperature the size of the

(Continued on p. 100)

*Abstract of "Three Basic Stages in the Mechanism of Deformation of Metals at Different Temperatures and Strain Rates", by W. A. Wood, G. R. Wilms and W. A. Rachinger, *Journal*, Institute of Metals, May 1951, p. 159.

TESTS PROVE
LOW SHRINKAGE
OF... Park NON-BURNING CARBURIZERS



YOU CAN CUT your consumption of carburizing compound up to 50% by using PARK NON-BURNING pack-carburizers. Shrinkage losses are low and carburizing activity is maintained by additions of as low as 1 to 16. Moreover, these materials are ideal for direct quenching because they do not burn after removal from the furnace.

CASE DEPTHS furnished by PARK NON-BURNING carburizing compounds are consistent with steels' ability to absorb carbon during any given time-temperature cycle. In addition, undesirable carbon build up at steel surfaces is prevented, particularly on alloy steels. Surface carbon concentrations rarely exceed 1% with conventional carburizing temperatures.

THE ENERGIZING CHEMICALS in PARK NON-BURNING carburizers are evenly distributed throughout the granules. The compound retains its carburizing potential indefinitely and is not damaged by handling. Its weight per cubic foot is considerably less than smeared coke type materials.

The smaller sizes of PARK NON-BURNING carburizing compounds are ideal for packing small parts and a special grade prevents copper migration on copper plated parts.

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...if you want to carburize selectively in either pack or gas carburizers . . . or prevent decarburization on high alloy steels during heating for hardening. Bulletin on request.

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**In a letter to the editor of* PLANT ENGINEERING, *Aug. 10, 1951.*

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Your plant could be one of the emergency sources Mr. Wilson is talking about. Appoint a scrap and salvage team. Study plant layout to determine what can be scrapped. Then turn it up and turn it over . . . to your scrap dealer for cash.

Check your plant for obsolete, broken, worn-out and irreparable:

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☐ motors ☐ machine bases ☐ tools ☐ chain ☐ structural steel ☐ valves ☐ starters
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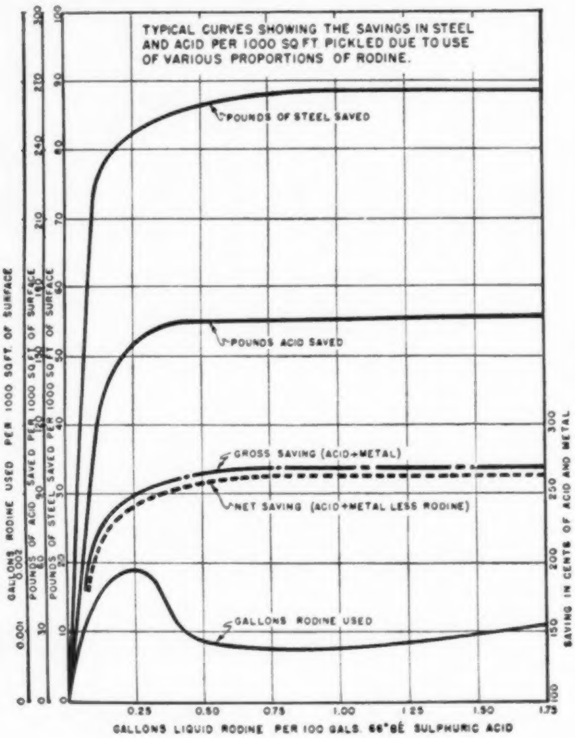
Technical Service Data Sheet

Subject: EFFICIENT PICKLING WITH "RODINE"®

A. SAVINGS POSSIBLE WITH "RODINE"



B. TYPICAL APPLICATION OF "RODINE"

Pickling shell cases in uninhibited muriatic or sulfuric acid contributes to their embrittlement and makes it difficult to draw them without breakage. By adding a small amount of "Rodine" to the pickle bath, embrittlement is suppressed and more than enough acid is saved to pay the costs of the inhibitor.

ACP WRITE FOR DESCRIPTIVE FOLDER ON "RODINE" AND INFORMATION ON YOUR OWN PICKLING PROBLEM. ACP

Basic Stages of Deformation

(Continued from p. 98)

substructure would approach the size of the grains. When this occurs, the grains cannot change shape by subdivision and internal block movements.

No trace of slip and no trace of substructure was found during deformation studies at high temperatures and low strain rates. At a strain rate of 0.1% per hr., slip predominated at temperatures up to 200° C.; the cell mechanism appeared between 250 and 350° C. The boundary microflow mechanism was found to be operative between 250 and 350° C. when the strain rate was reduced to 0.01% per hr. X-ray back reflection photographs showed that a specimen extended 8% at 350° C. in 764 hr. had essentially the same type of pattern as the initial material. An additional examination of this specimen after 57% extension revealed no dispersion of the initial reflections into secondary smaller ones as was observed on similar specimens tested at higher strain rates or lower temperatures.

Metallographic examination confirmed the X-ray results. No sign of slip lines or of sub-boundary markings were found. Further experiments showed that grains did not disappear and newly recrystallized grains form. X-ray photographs were taken of the same area and the same reflection spots remained after deformation. Thus, the third stage was considered to be one in which a considerable deformation of the grains may occur without internal block movements.

The term "micromovement" was used to describe a movement that is too localized to disturb the internal homogeneity of the grain. During the "boundary microflow" stage, creep was not observed to be accompanied by strain hardening. Elongations of over 100% were obtained without strain hardening.

In general, it appeared that if the rate of strain is very small, the associated changes in shape can be produced by micromovements alone, internal block movements need not occur. If the rate of strain is increased, a stage will be reached when micromovements alone cannot accommodate the imposed rate of strain, and the movement of blocks within the grains occurs. At still higher rates of strain, the dissociation of grains becomes more

(Continued on p. 102)

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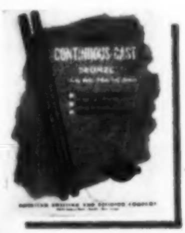
You can get Continuous Cast bronzes made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ on special arrangement.

216 sizes of the standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths for convenience at warehouses in principal cities across the country. Distributors will cut the warehouse stock to suit your specific requirement . . . *long or short.*



For more data see your Asarco distributor, or send the coupon for a 12-page color catalog that contains complete technical data.

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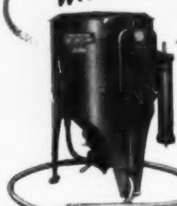
for Blast Cleaning... Dust Control... Precision Finishing

Blast Clean with this Portable Unit!



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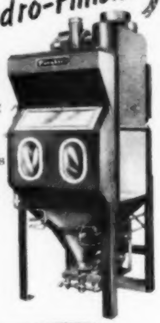
Speed Polishing with Hydro-Finish!



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Basic Stages of Deformation

(Continued from p. 100)

drastic — small blocks are formed which are accompanied by disordered material. The unit of block movement is the element bounded by slip planes. The familiar slip mechanism prevails.

Strength and strain hardening are discussed in view of the postulated mechanisms of deformation. The strength seemed to vary inversely with the size of the substructure. Strain hardening is thus presumably due to the formation of a smaller substructure.

Creep should occur when the substructure attains an equilibrium condition, and there should be no strain hardening. The mechanism of creep was thought to be "boundary micromovement" while the phenomenon of transient creep was considered to be due to a preliminary breakdown of the grains before the establishment of an equilibrium state of the microstructure. The equilibrium state existed during the "steady state" portion of creep.

E. R. Parker

Isothermal Transformation of Nickel Steels*

The staff of the research laboratories of the Mond Nickel Co., Ltd., Birmingham, England, have summarized the techniques employed for determining isothermal transformation diagrams, the influence of various alloying elements on the transformation behavior and the limitations in the practical application of these diagrams. In view of the ease with which changes in length can be measured, the laboratory adopted the dilatation method as the principal technique for determining these diagrams. Since the dilatation method does not adequately differentiate overlapping transformations or indicate the degree of completion of a reaction, dilatometric data are supplemented by metallographic examination of appropriately treated specimens.

The general characteristics of austenite decomposition were discussed in terms of a B. S. EN 25 steel (2½% nickel-chromium-molybdenum, 0.3% carbon) as a prototype

(Continued on p. 104)

*Abstract of "Isothermal Transformation Diagrams for Nickel Steels", *Metallurgia*, Vol. 43, May 1951, p. 234-242, and June 1951, p. 280-288.

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Isothermal Transformation of Nickel Steels

(Continued from p. 102)

for other steels. In the B. S. EN 25 steel, the formation of proeutectoid ferrite preceded the formation of pearlite at all temperatures in the pearlite range, and the pearlite and bainite ranges were clearly separated with respect to time and temperature. Microstructural variations as a function of transformation temperature were typical of those in medium carbon alloy steels.

In summarizing the literature on the influence of various elements on the rate of transformation in the pearlite and bainite ranges, it was indicated that the pearlite reaction is retarded as the carbon content is increased up to the eutectoid composition; however, when the carbon content is increased beyond the eutectoid composition the pearlite reaction is accelerated. In the bainite range, the transformation rate continuously decreases with increasing carbon content.

Nickel and manganese retard the pearlite and bainite reactions to about the same extent. Copper and silicon behave in the same fashion, although the magnitude of their effect is considerably less than that of nickel or manganese. Cobalt has been observed to increase the transformation rate.

Molybdenum and chromium raise the temperature range in which the pearlite reaction occurs. These elements lower the temperature range for the bainite transformation and exert a much smaller retarding effect on the bainite than on the pearlite reaction. Isothermal transformation diagrams for steels containing appreciable percentages of these alloying elements exhibit a bay of relatively great austenite stability between the pearlite and bainite ranges.

Controversial reports concerning the influence of vanadium on the transformation rate arise from the persistence with which vanadium carbide resists solution in austenite. Vanadium will retard the transformation rate if the carbides are dissolved during the austenizing treatment.

Boron strongly retards the formation of proeutectoid ferrite but exerts a much weaker effect on the pearlite and bainite reactions. Increasing grain size also retards the reactions in the pearlite range but exerts little or no effect on transformation in the bainite range.

Although little systematic infor-

mation is available concerning the effect of the simultaneous addition of several alloying elements on the transformation behavior, certain combinations are believed to be particularly advantageous. Thus, the hardening power of nickel is improved by the presence of manganese, chromium, or molybdenum; in turn, these elements are more potent in the presence of nickel than they are when used alone.

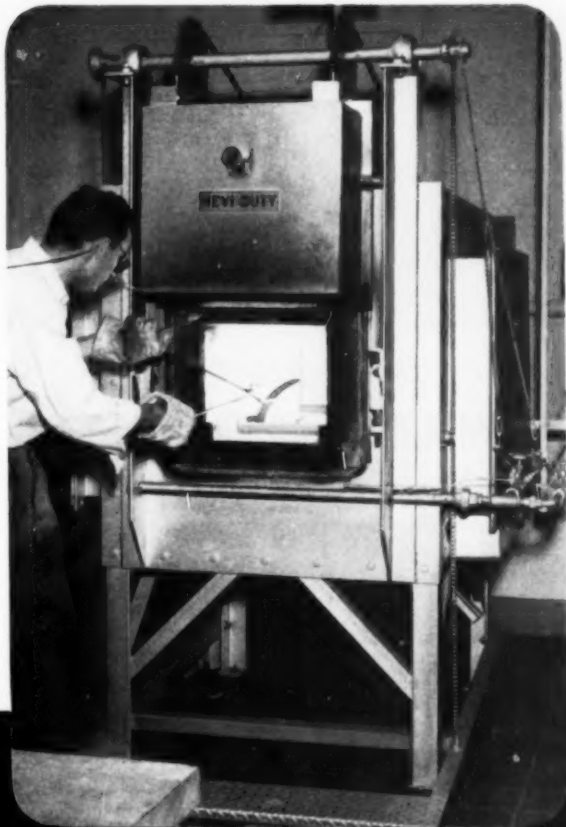
With the exception of cobalt, carbon and all alloying elements have been observed to lower the M_s temperature. Carbon, however, exerts by far the strongest effect in this respect. Because a high M_s temperature reduces the tendency toward quench cracking and austenite retention, the smaller effect of the alloying elements on this temperature is regarded as being advantageous.

Although most low-alloy steels have M_f temperatures above room temperature, retained austenite is frequently observed in these steels. Although the presence of this austenite may arise from inhomogeneity in the austenite, it is most likely to occur from relatively short austenizing cycles — as, for example, the austenizing resulting from welding. The authors indicate that at least part of the retained austenite may be associated with the formation of proeutectoid ferrite or upper bainite during the quenching process. The removal of this retained austenite by subzero treatment is rendered more difficult by the phenomenon of stabilization that takes place during the holding at intermediate temperatures.

To obtain the optimum combination of mechanical properties, the formation of nonmartensitic transformation products must be avoided during quenching operations. An examination of isothermal transformation diagrams permits choosing compositions with sufficient hardenability to avoid transformation in the pearlite range; however, the formation of low-temperature bainite frequently must be tolerated. The low-temperature bainites are generally less detrimental to the mechanical properties than are the products resulting from transformation in the pearlite range.

In the application of isothermal transformation diagrams to specific heat treating problems, allowance must be made for the fact that the diagrams are based on samples taken from a single heat of steel and that variations in composition from heat to heat will introduce

(Continued on p. 106)



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Isothermal Transformation of Nickel Steels

(Continued from p. 105)

corresponding variations in the transformation behavior. Further variations in transformation behavior arise because the diagrams are based on the study of small samples. Important variations in transformation behavior have been observed for specimens removed from different positions within a single billet.

Cooling curves are presented for several positions within oil quenched and air cooled bars of 1 to 6-in. diameter. As an approximation, these curves may be used for determining the center cooling curve of other simple shapes by employing the center cooling curve for the size of round whose ratio of volume to surface area most closely approximates that of the shape under consideration. Superposition of these cooling curves on the isothermal transformation diagram then provides a rough approximation of the hardening conditions which can be attained in a given quenching operation. However, the applicability of such a procedure is quite limited because the isothermal transformation diagram does not accurately represent the transformation behavior under continuous cooling conditions. Borderline cases therefore must be checked under the actual heat treating conditions.

The suitability of a particular composition for martempering and other interrupted heat treatments can be judged from the isothermal transformation diagram, since the primary requirement for these applications is that the induction period be sufficiently long to permit temperature equalization without the initiation of transformation. In the application of isothermal transformation diagrams to austempering and isothermal annealing processes, the transformation time employed should be two or three times as long as that indicated on the transformation diagram in order to account for the variation in transformation behavior from heat to heat and within a given heat.

With the exception of compositions relatively rich in chromium or molybdenum, austenizing times and temperatures can be varied through fairly wide limits without appreciably affecting the transformation behavior. The type of pearlite formed is dictated in part by the austenizing temperature adopted. Low austen-

(Continued on p. 108)

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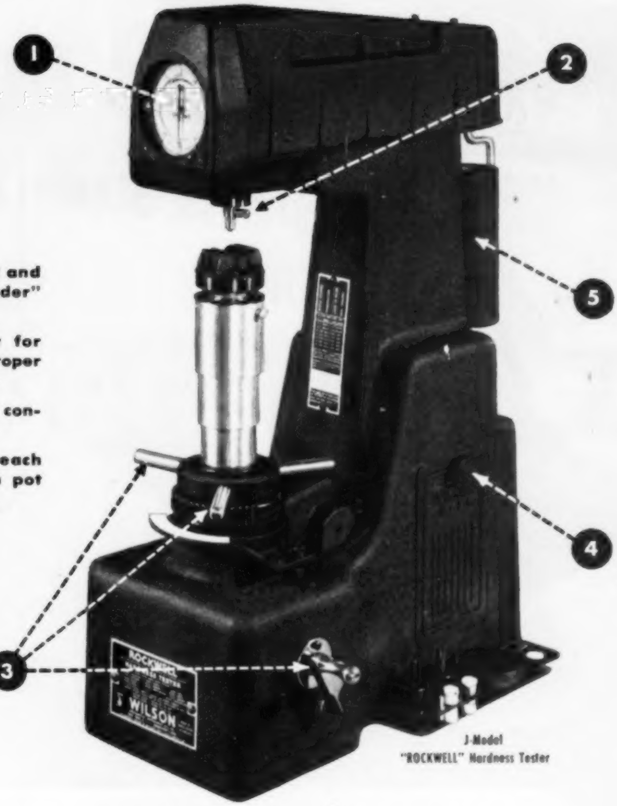

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Isothermal Transformation of Nickel Steels

(Continued from p. 106)

izing temperatures favor spheroidal carbides whereas high temperatures produce a lamellar structure.

Isothermal transformation diagrams are presented for thirteen 0.3 to 0.4% carbon steels with various combinations of alloying elements in the range 0.75 to 4.25% nickel, 0.44 to 1.38% manganese, 0.22 to 1.44% chromium and 0 to 0.51% molybdenum. In general, when the chromium content was less than approximately 0.5% and the molybdenum content was less than 0.2%, the isothermal transformation diagram consisted of a single curve in the shape of a "C", regardless of the nickel and manganese contents. In these compositions, the pearlite range may be displaced to longer times at the upper limits of the chromium and molybdenum contents, thereby giving a somewhat distorted "C" curve.

At higher chromium (0.7% and up) and molybdenum contents, the isothermal transformation diagram consists of two "C" curves clearly separated with respect to temperature. A bay of austenite stability exceeding one day in duration was found only in steels having combinations of nickel, chromium, and molybdenum in amounts greater than 2, 0.7, and 0.3%, respectively.

R. F. Hehemann

Blowing a Thomas Converter With Oxygen*

The experimental program on the use of oxygen-enriched blast in the Thomas (basic) converter, sponsored by the French Steel Research Institute (IRSID), appears to have been conducted principally to explore the scrap-melting potentialities of the converter. Complete metallurgical and operating data are reported for each blow.

The experiments were conducted in converters of 21-ton capacity. The oxygen was supplied by a battery of manifolds fed into a common line controlled by a pressure-operated flow regulator. Because of limitations of oxygen supply the maximum enrichment of the blast

(Continued on p. 110)

*Abstract of "Experiments in Blowing a Thomas Converter With Oxygen", by G. Husson, Series A—No. 5, March 1949, L'Institut de Recherches de la Sidérurgie (IRSID), Paris.

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Blowing a Thomas Converter With Oxygen

(Continued from p. 108)

obtained, determined by analysis, was 38% oxygen content. Blast pressure was varied during the blow, beginning at 25 psi. (sometimes lowered to 20 psi. if slopping occurred), then gradually raised to 35 psi. toward the end of the blow.

The first three experimental blows, with oxygen contents in the blast of 24, 29 and 39%, showed notable decrease in blowing time and indicated the possibility of melting relatively heavy scrap additions. With 39% oxygen the blowing time was 50% less than for the preceding blow without oxygen, and the scrap addition was approximately 25% of the weight of the hot metal charged. The nitrogen content of this blow was 0.004%, which is comparable to Martin (basic openhearth) steel.

On the basis of the initial tests, it appeared that oxygen contents of less than 30% would have only limited value in converter operation; however, because of limitations of oxygen supply, most of the ensuing tests were made aiming for 30% oxygen in the blast.

A blow made with iron that was physically and chemically cold, finished at satisfactory temperature with the oxygen-enriched blast, while the previous charge, blown with air, had required a 90-lb. addition of 75% ferrosilicon to the iron. In blowing iron of 0.66% silicon content, apparently high for the Thomas process, considerable difficulty was encountered with slopping; however, substantial scrap additions were melted, roughly 18% of the iron charge.

The author's conclusions, covering the results obtained with 12 oxygen-enriched blows, are essentially as follows: With 40% oxygen, the practically useful limit was reached with the technique employed because the blowing time had been reduced to the practical minimum for melting the heavy scrap addition used. With 30% oxygen in the blast, approximately 390 lb. of scrap could be melted per ton of iron. The economics of oxygen enrichment hinges upon the relative costs of oxygen and scrap.

In addition to the operating advantages obtained by melting scrap in the converter and in handling cold iron there appear to be some metallurgical possibilities from oxygen enrichment. While addi-

(Continued on p. 112)

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Blowing a Thomas Converter With Oxygen

(Continued from p. 110)
tional data would be necessary to establish the effects upon nitrogen content, it is interesting to note that of the 12 blows made with oxygen-enriched blast, six were in the range of 0.004 to 0.007%, with a maximum of 0.010% nitrogen. The companion blows with air had from 0.008 to 0.013% nitrogen.

The phosphorus contents reported — as much as 0.082% — seem rather high even for Thomas steel, but apparently the lime addition represented a compromise between what is metallurgically possible and what is expedient from the operating viewpoint. The iron averaged approximately 2.00% phosphorus.

While there is a very definite saving in blowing time, the author places no stress on this point, although it would seem that if maximum output were an important factor in a particular plant, oxygen enrichment might be desirable from this point of view also.

The results obtained with oxygen-enriched blast in melting scrap parallel those of experiments conducted in the United States with the acid Bessemer process (see abstract "Increasing Bessemer Production" in *Metal Progress* for September 1951, p. 130).

S. Feigenbaum

Later Work*

More detailed work was undertaken in 1950 following the initial test blows of 1947. The 87 heats studied were divided into nine different groups, the details of which are listed below:

1. Blast enriched to 30% oxygen with steel scrap additions in the converter.
2. Blast enriched to 30% oxygen and roll scale addition plus scrap charge used with normal air blast.
3. Same scale charge as used in normal air blow plus increased scrap with 30% oxygen blow.
4. Blast enriched to 30% oxygen with Lorraine iron ore addition only. No scrap or scale used.
5. Blast enriched to 40% oxygen with greatly increased scrap charge

(Continued on p. 114)

*Abstract of "Blowing Tests in a Thomas Converter With Oxygen-Enriched Air", by P. Leroy and E. Devernay, Series A — No. 26, March 1951, L'Institute de Recherches de la Sidérurgie (IRSID), Paris.

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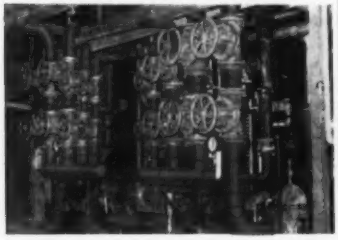
Aluminum Fills The Bill For Chemical Piping Systems

Piping engineers, always on the lookout for more serviceable materials, have found that aluminum is highly desirable for a growing list of applications. It leads to substantial savings as well, in some instances.

A new aluminum piping installation in the Spencer Chemical Company's plant at the Indiana Arsenal, near Charlestown, Indiana, offers an interesting example of the advantages that aluminum can provide.



Spencer's "Spensol", a solution used in the manufacture of mixed fertilizers, is the fluid conveyed. It consists of ammonia, ammonium nitrate and water. The temperature of this highly corrosive fluid is 100° Fahrenheit at a pressure of 75 psi. Tube-Turn welding elbows, tees, forged flanges and Van Stone stub ends of 3S-F aluminum were employed in the fabrication of the piping to obtain corrosion resistance, efficient flow conditions and prevent leakage of this volatile product.

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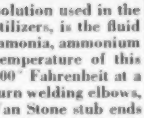

Strength, Mobility Important Factors in Designing With Aluminum, Actual Case Histories Show

Most progressive engineers are becoming increasingly aware of the importance and desirability of using aluminum in present and future designs. The strength and light weight of aluminum are also important factors to consider for many structural purposes.

Whether in fixed structures or in those designed for mobile use, aluminum's advantages are readily apparent. The new technical handbook, "Aluminum Structural Design", gives several interesting examples of the wide variety of uses to which aluminum can be put.

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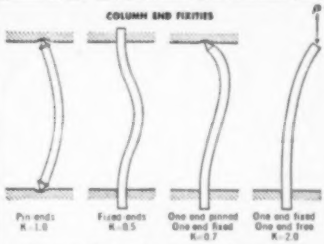
Upright Scaffolds Co. photo.

This portable scaffolding can be erected to several stories in a very short time. Lightweight aluminum simplifies transportation. Structural aluminum proves ideal for this purpose and others of like nature...television and radio antennas, machinery and equipment dollies, truck trailer bodies, etc.

From a purely technical standpoint, the new "Aluminum Structural Design" is extremely valuable. For example, data presented in this book should enable the engineer to design an original structure of aluminum, or to convert an existing structural design from some other material to aluminum.

Complete information is presented on mechanical properties of aluminum alloys plus a comprehensive discussion of structural design and fabricating considerations. Especially valuable are the formulas and tabular data.



Book includes drawings such as above.

Information contained in this book, as well as others in the Reynolds Library of Technical literature, may give you an idea how the proper use of aluminum may improve your product design or manufacturing process. Why not write now for your *free* copy of this handbook, "Aluminum Structural Design", as well as a complete list of other design and fabrication material available? Please send your request on business letterhead, otherwise price of the book is $1.00.

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(Continued From Preceding Page)

Four-Part Sheet Approved For Military Packaging

Reynolds Metals Company has announced government approval of the new four-part sheet, RM-112. This improved packaging material consists of four materials stoutly bonded with special adhesives.

Photo showing construction of RM-112 four-part sheet.

An improved and tougher version of Reynolds RM-101, the new sheet is constructed in the following manner: Scrim backing provides toughness, the plastic film gives flexibility, the .001 Reynolds Aluminum Foil means perfect moisture-vapor and water-vapor protection and the vinyl sheet furnishes perfect sealing.

This is the ideal barrier for protecting motors, generators, electronic equipment and other military items packaged by the "Floating Barrier Method"—specification approved as Type II material under AN-B-20, Barrier, Flexible Sheet Moisture Vapor plus Exhibit 618 and Class A, Type I material under MIL-B-131A, Barrier-Material; Water-Vapor Proof, Flexible.

Upon request, free samples are available to manufacturers and converters for preparing their qualification samples. This applies not only to RM-112, but to other Reynolds Military Barrier materials: RM-240, approved under JAN-P-117, type II (replacing AR-61); RM-260, approved under JAN-117, type I (replacing AR-63); RM-201, currently being used for dehydrated soup packages in rations.

Call the Reynolds Office listed under "Aluminum" in your classified telephone directory. Or, write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Aluminum Roofs and Buildings Cut Heat, Increase Efficiency

Industry can take a tip from farmers on reducing the inside temperature of buildings. Proof of this was offered by John L. McKitrick, Agricultural Consultant, in a recent speech before the American Society of Agricultural Engineers.

Mr. McKitrick showed that it can take three times as much feed to put 100 pounds weight on a hog at 85° as it does at 60°. Through use of aluminum roofs and buildings on the farm, temperatures during the summer can be lowered as much as 15° inside.

If reduction of summer heat can increase efficiency for farm animals, it is entirely conceivable that it can increase human efficiency. When designing building products or new plants and additions, consider the many advantages of aluminum—heat and light reflection, no rust, low maintenance, long life, lightweight, ease of fabrication and erection.

Aluminum Perfect Answer to Poultry Processing Problems

Gordon Johnson Company Calls on Reynolds Aluminum for Sanitary Advantages in Poultry Processing Equipment

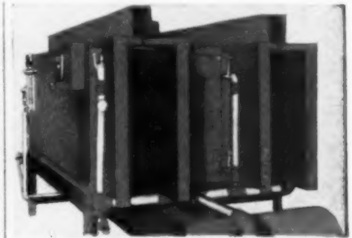
"The processing of poultry, with its attendant factors of blood, viscera, the constant use of steam and boiling water creates equipment problems which can be answered only through the use of aluminum," says the Gordon Johnson Company of Kansas City, Missouri.

Designers and manufacturers of equipment for the poultry industry, this company has solved its problems of material for such equipment through the use of easy-to-clean, sanitary, Reynolds Aluminum sheeting.

The machine illustrated shows the extent to which aluminum sheet is used for "skins" or coverings. Rust and corrosion resistance are the obvious advantages in this application, but lightweight, easy fabrication and rugged dependability also commend aluminum over other materials.

Marsh Steel Corporation, the Reynolds distributor in North Kansas City, Mo., Denver and Colorado Springs serves the Gordon Johnson Company on aluminum requirements for this machine and also for gizzard processing and other equipment.

If this use of aluminum to solve a design problem suggests a way in which aluminum can benefit your products, why not contact the Reynolds Office or distributor listed under "Aluminum" in the classified telephone directory? Or, write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.



Automatic Poultry Scalding Machine

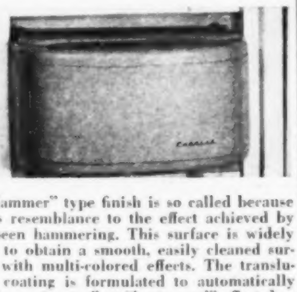
Polychromatic Finishes With Reynolds Aluminum Non-Leafing Pigment Cut Costs, Improve Appearance!

Aluminum pigmented coatings are usually thought of as producing the typical silvery surface associated with aluminum. This is accomplished with "leafing" aluminum pigment when the aluminum "flakes" in the vehicle rise to the surface to present a brilliant, uniform aluminum sheen.

By special processes, patented by Reynolds Metals, this "leafing" characteristic can be eliminated. The resulting "*non*-leafing" aluminum pigments do not rise to the surface but remain evenly dispersed in the lacquer or enamel as it sets up. The randomly oriented flakes catch light at different angles to produce an effect of both depth and iridescence.

There are three types of Polychromatic finishes available to you for your products, regular, hammer and wrinkle type finishes.

"Regular" type is the most iridescent of the polychromatic finishes now in such great demand for automobiles. Either translucent enamel or lacquer may be used as a color base.



"Hammer" type finish is so called because of its resemblance to the effect achieved by ballpeen hammering. This surface is widely used to obtain a smooth, easily cleaned surface with multi-colored effects. The translucent coating is formulated to automatically produce a "crater" or "hammered" effect during drying. It will hide minor surface defects and blemishes. A typical application is window air conditioning units such as the one shown in the preceding column.

"Wrinkle" finishes are widely used for a glare-free surface on reproduction machines and other office equipment. Reynolds non-leafing aluminum pigments are combined with opaque enamels to achieve defect-hiding properties without buffing or sanding. The wrinkle effect is produced by a short baking operation.

Take advantage of Reynolds experience in the industrial finishes field. Reynolds technicians will be glad to work with you and your finishes supplier to achieve just the right polychromatic finish for your product. For a copy of the FREE four-page brochure telling more about polychromatic finishes contact the Reynolds Office listed under "Aluminum" in your classified telephone directory. Or, write the Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

REMEMBER . . . *aluminum* is the only mass-produced material that costs less now than before World War II!

(Advertisement)

CLEAN SHEETS

You can make better products from clean, smooth, flat Chase Sheet Brass and Copper. Chase sheets are free from oxide coatings, excess grease and oil. That means they are uniform in color and have a bright finish.

CMP orders. We can make favorable mill deliveries on authorized Controlled Materials orders. In many cases our warehouses can ship from stock. Your inquiries are invited.

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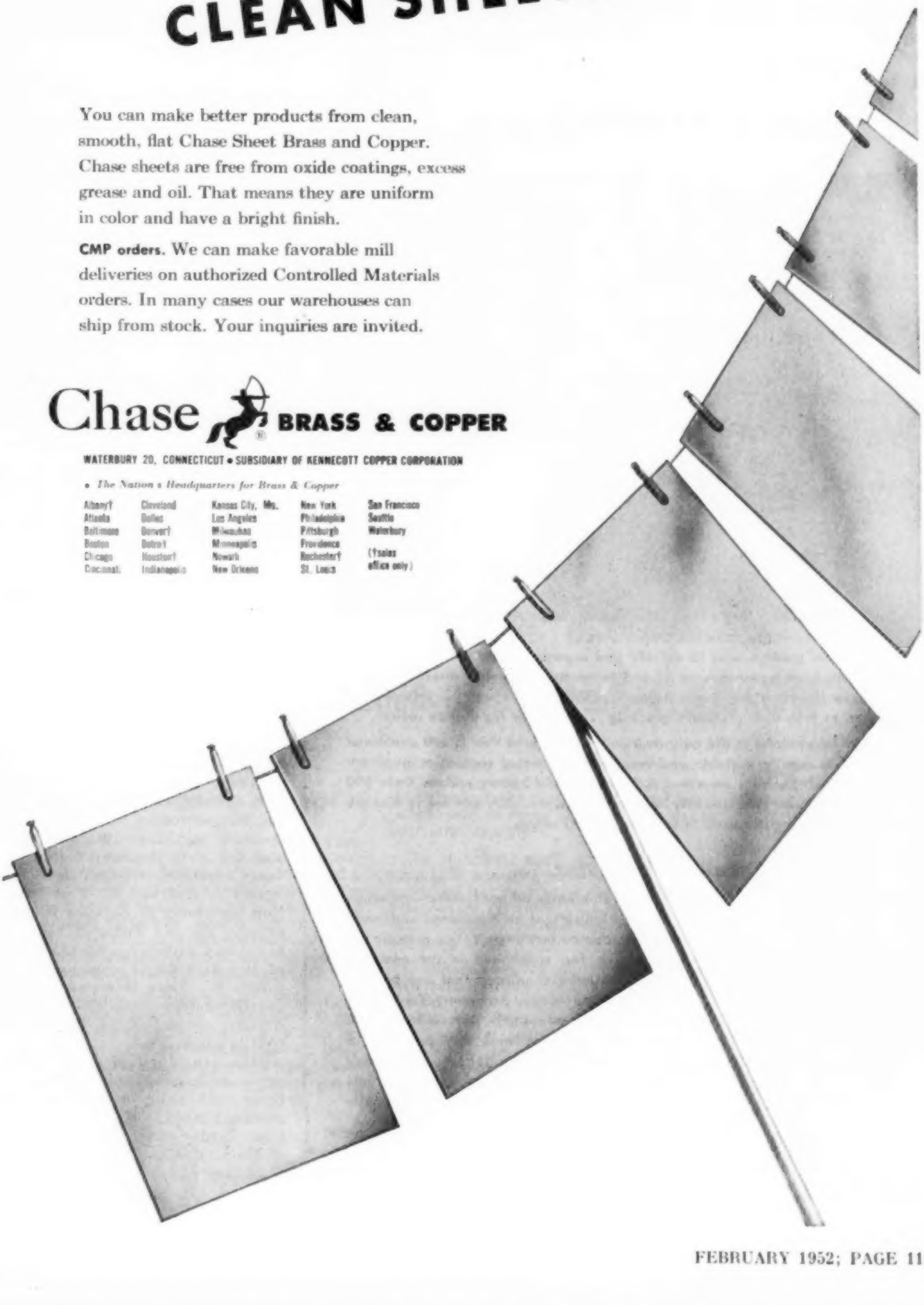
Boston	Detroit	Minneapolis	Providence	
Chicago	Houston†	Newark	Rochester†	(†sales
Cincinnati	Indianapolis	New Orleans	St. Louis	office only)

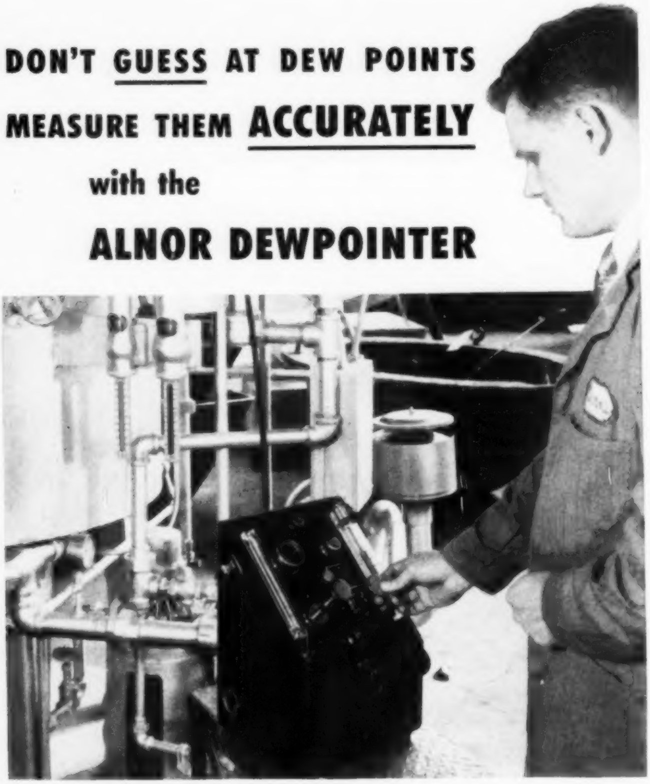


DON'T GUESS AT DEW POINTS

MEASURE THEM ACCURATELY

with the

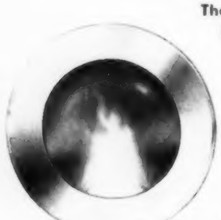
ALNOR DEWPOINTER



Here's the modern way to quickly and *accurately* read the dew point in controlled atmospheres—the Alnor Dewpointer. Its simple, direct operation assures laboratory accuracy by non-technical personnel . . . in the field, plant, or wherever precision checking is necessary for quality results.

The Dewpointer is the only instrument of its kind that is self contained . . . it is readily portable and requires no external coolant or auxiliary apparatus. Operates on either A.C. or enclosed battery power. Over 600 large industrial concerns rely on Dewpointer precision and many find the instrument pays for itself in savings on CO_2 alone.

Guesswork Eliminated



The Dewpointer eliminates all guesswork—as when trying to read indications on a polished surface in other less accurate instruments. You actually see the dew or fog suspended in the enclosed chamber—under conditions that can be controlled and reproduced accurately. You'll want to know more about this unique instrument that brings portable laboratory precision to your dew point determinations, so send today for your copy of the Dewpointer Bulletin. Illinois Testing Laboratories, Inc., Rm. 523, 420 N. La Salle Street, Chicago 10, Ill.

Alnor

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Later Work

(Continued from p. 112)

to control temperature. No scale or iron ore was used.

6. Blast enriched to 40% oxygen with both increased scale and steel scrap addition.

7. Blast enriched to 40% oxygen with increased scrap and large lime addition.

8. Heats with 43 and 32% oxygen with large scrap addition. Sixty of the 152 bottom tuyeres were plugged to reduce blowing time.

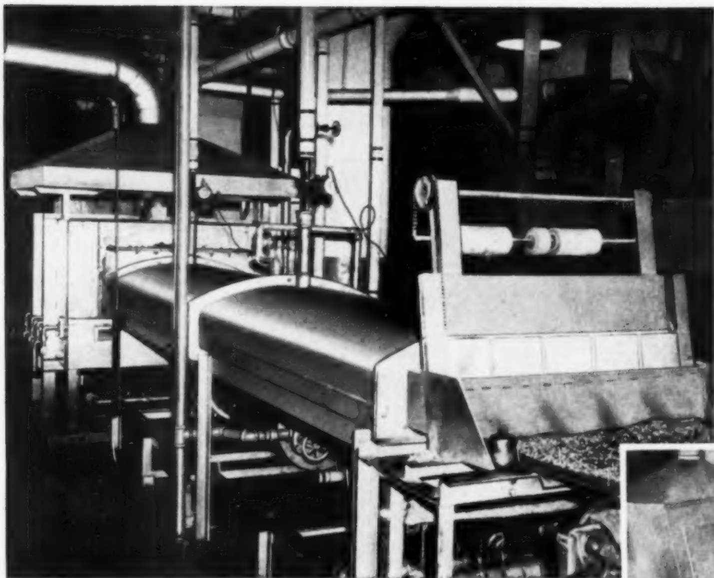
9. Blast enriched to 25% oxygen plus scrap addition.

In order to avoid the influence of variable factors, check blows, using ordinary air with usual scrap or scale additions for standard practice, were made before and after each enriched air blow and comparative data on all special and check heats recorded for comparison. The temperature of the hot metal charged and the final bath temperature after slagging was determined with an immersion pyrometer. The hot metal temperature varied from 2145 to 2300° F. (1175 to 1260° C.) and the final steel temperature from 2860 to 2985° F. (1570 to 1640° C.). All scrap additions originated with rail sections cut to even lengths to enable accurate measurement and avoid variations in melting rate due to different sizes. Roll scale was dried and scale additions up to 55 kg. (121 lb.) per metric ton (2204 lb.) could be used without getting a too violent reaction. Most additions of scrap, scale and iron ore were made before blowing. The hot metal charge was kept at 16 metric tons (35,260 lb.).

The effect of enriched blast on the nitrogen content of the steel, the elimination of phosphorus, the residual manganese after blowing and the FeO content of the slag were carefully checked and discussed in great detail. The discussion pertaining to nitrogen is quite cloudy; the hot metal is reported to contain 0.006% N_2, whereas some of the final blows contained only 0.005% N_2. Since American pig iron usually contains 0.093% N_2, the high nitrogen content of the Thomas pig iron is surprising.

The standard air-blown heats show an average of 0.010% N_2; those with scale or ore additions averaged 0.008% N_2; 30% oxygen blast heats with maximum scale addition of 55 kg. showed 0.005% N_2. This was the lowest nitrogen reported. Heats blown with 40 to

(Continued on p. 116)



Charging end of the Stewart Bright Annealing Furnace showing blanks for P-K self-tapping screws coming off the Nichrome* conveyor belt made by Audubon Wire Cloth Corp. Furnace has been in continuous operation for more than 35,000 hours.

Discharge end of the furnace, at Parker-Kalon Corp., New York. Feeding is by an automatic electrically operated loader.

NICHROME* muffle passes 35,000-hour mark in non-stop performance at PARKER-KALON®

. . . and it's still going strong!

Does that make the Parker-Kalon Corp. happy? We should say so! Especially when they recall how, every year and a half, they used to mark time during a two-week shutdown. For that's how often they had to take down their annealing furnace to install a new muffle and belt. And the cost wasn't the worst of it . . . though it was plenty. What really hurt was the disruption of production schedules.

But that's all history now. Parker-Kalon anneals and normalizes its famous P-K self-tapping screws, thumb screws, wing nuts, and socket screws in a Sunbeam Stewart Bright Annealing Furnace equipped with a Nichrome* muffle and metal-woven belt. It operates at high annealing and normalizing temperatures, and handles a load that P-K's Production Manager, Harold Rosenberg, modestly describes as "substantially in excess of the 500-pounds-per-hour rated capacity."

The Nichrome* muffle and belt have been running at operating temperature for 35,000 hours, and they have never known a shutdown in four years. Yet neither shows any appreciable signs of wear or breakdown. And they are still going strong.

In similar ways, for over 35 years, we have been helping manufacturers meet their heat-treating requirements, to speed up operations, increase production, and cut costs. If you have such a problem, we invite you to consult with us. Although the present emergency's demands upon our resources are unprecedented, we shall gladly serve you to the limit of our ability.

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Later Work

(Continued from p. 114)

43% O_2 enrichment showed no improvement in nitrogen, but this is to be expected if the hot metal contained 0.006% N_2. The authors conclude from this sketchy data that the maximum advantage in respect to nitrogen content in the finished steel is obtained with 30% oxygen and that further enrichment is not necessary.

There was no correlation between final nitrogen or final phosphorus content in the steel nor any relation between the residual manganese in the bath. Variation of oxygen content of the blast showed no relation to the final phosphorus and manganese. The phosphorus (final) did reach an approximate equilibrium with the iron content of the slag when the latter value reached 10%. The final iron content of the slag was not increased above normal levels by oxygen enrichment of the blast. In the 87 heats processed, the iron in the slag varied from 6.2 to 12.4% and the phosphorus from 0.035 to 0.086%; higher phosphorus heats showed lower iron content.

A detailed discussion of the effect of oxygen enrichment on the thermal equation of converter operation is given. The elements which influence the heat generated in blowing are the relative amounts of carbon oxidized to CO or CO_2, the sensible heat content of N_2, the rate of blowing and the heat capacities of the different coolants, scrap, scale or iron ore added with the charge.

Although only a few, and admittedly questionable, samples of effluent gases were taken, a long discussion of the $CO:CO_2$ ratio in air-blown heats and higher oxygen-blast heats is given. Some of the tables indicate a slightly greater amount of CO_2 in the escaping gases, especially during the final stages of the carbon oxidation. The data are insufficient to permit any calculation of increased heat generation from the use of oxygen enriched blast.

The reduced amount of nitrogen blown with enriched oxygen blast leads to a diminished heat loss from this factor. Using the value of 62.5 cu.m. of O_2 to oxidize a ton of hot metal or 300 cu.m. of air, a formula for the heat saving due to reduced N_2 is derived. This is

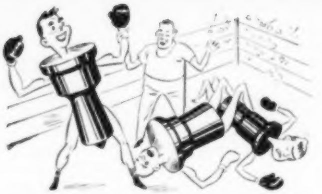
$$Q = \left(3 - \frac{62.5}{X}\right) \cdot 47{,}300$$

(Continued on p. 118)

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation



Omega Tool Steel Outpunches Two Air-Hardening Grades

Our Omega tool steel took on two different air-hardening grades and outpunched them to win a unanimous decision. It all came about when one of our customers began the production of steel posts to be used for barbed wire entanglements by our armed forces. Made from re-rolled steel rails, the posts had to have several holes punched in them. We were asked to suggest a tool steel for this tough, cold-punching work.

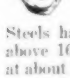
It looked to us like a job for Omega, our silico-manganese grade that's tops for cold-battering and heavy shock work. The customer made up some punches from Omega and also some from two different air-hardening steels.

The production trial gave the customer a clear-cut result. The punches made from the air-hardening tool steels broke in less than eight hours. Those made from Omega needed only slight redressing after eight hours . . . in which time some 4000 posts were punched. Since then the Omega punches have stood up even better than the customer expected, saving steel and precious time.

There's nothing spectacular about this report. But it does illustrate the importance of starting with the right steel for the job.

Bethlehem tool steel specialists have the experience to help you get the most out of your tool steel, whether it's a problem of selection, tool design, machining, heat-treatment, or grinding.

Our Tool Steel Engineer Says:



Tool Steel Preheating Is Good Insurance

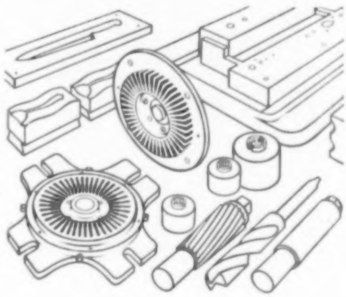
Steels having a hardening temperature above 1650 F should first be preheated at about 1200 to 1300 F. This shortens the heating time at the hardening temperature, helps to reduce excessive scaling and decarburization which occur rapidly at high temperatures.

Steels hardened above 2000 F should be preheated at about 1600 F.

8 TOOL STEELS for 90 PER CENT of ALL TOOL and DIE WORK

Reducing the number of tool steels you carry in stock simplifies tool room problems. It makes heat-treating easier and leads to lower costs.

Just eight mighty fine tool steels will handle 90 pct of all tool and die jobs:



CARBON AND CARBON-VANADIUM For general-purpose tools. Water-hardening, it produces a tough core and a hard, wear-resisting case. Easiest to machine and heat-treat.

BTR Oil-hardening steel of the manganese-chromium-tungsten-vanadium type. For more intricate tools requiring safer hardening and less distortion.

A-H5 Our 5 pct chrome, air-hardening grade for greater protection against cracking . . . and for less distortion and better wear-resistance than BTR.

LEHIGH H High-carbon, high-chromium steel. An air-hardening grade, it's first choice wherever maximum wear and minimum distortion are important.

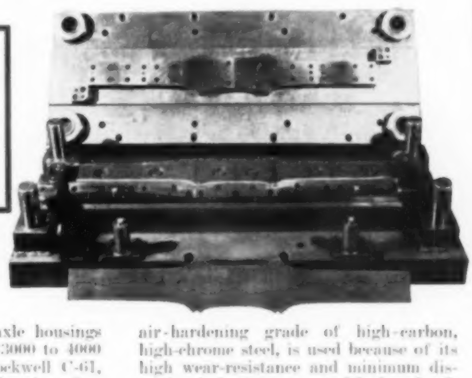
OMEGA For cold-battering tools. This silico-manganese steel combines hardness with maximum toughness for severe shock jobs on cold work.

67 CHISEL Our chromium-tungsten grade for various shock tools and master hobs. When carburized for extra wear-resistance, it retains a hard, tough core.

CR-MO-W This 5-pct-chromium hot-work steel is ideal for jobs involving shock, drastic temperature changes, and where heat-checking is a problem.

66HS Today's most popular type of high-speed steel, this tungsten-moly grade is ideal for nearly all cutting tools. It's the AISI M2 type.

Big Blanks for Axle Housings



This die blanks out rear-axle housings from 3/16-in. sheet steel—3000 to 4000 per shift. Hardened to Rockwell C-61, the die needs only slight redressing after producing 50,000 pieces. Lehigh H, our air-hardening grade of high-carbon, high-chrome steel, is used because of its high wear-resistance and minimum distortion in heat-treatment. It's deep-hardening, ideal for heavy-duty dies.

Bethlehem ULTRASONIC TESTED **Tool Steel**

Guaranteed Results from

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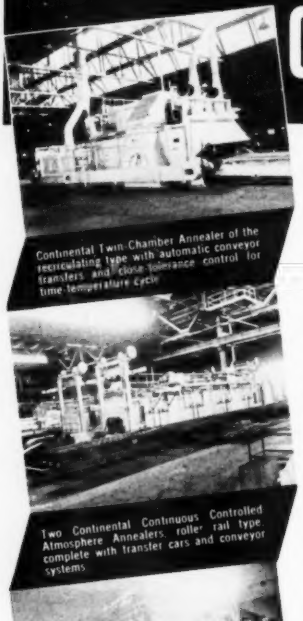

Continental Twin-Chamber Annealer of the recirculating type with automatic conveyor transfers and close-tolerance control for time-temperature cycle

Two Continental Continuous Controlled Atmosphere Annealers, roller rail type, complete with transfer cars and conveyor systems

Continental Stamping Annealer, continuous roller rail type, complete with baskets, handling conveyors, and automatic controls for work handling and temperature cycles

Six Continental "Top Hat" Cover Type Furnaces for bright annealing high carbon steel complete with gas generator and automatic controlled time temperature cycling

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Later Work

(Continued from p. 116)

where Q is the heat gained per ton of metal blown when the oxygen content of the blast is X. This equation yields a hyperbolic curve from 20.8 to 100% oxygen blast. The sensible heat of the diminished amount of nitrogen was obtained from the mean specific heat of nitrogen, 0.35 cal. per cu.m. per °C. times temperature of 1350° C.

Similar calculations of the heat capacities of coolants, steel scrap and scale were made and this heat absorption was equated to the heat saved from reduced nitrogen blown and a relation between the enriched oxygen blast and increased amount of coolant added obtained. In these test heats the additions were made on this basis and the uniformity of the temperature of the final bath indicates the plausibility of the empirical formulas derived. For steel scrap the equation is:

$$F = \left(3 - \frac{62.5}{X}\right) \cdot 147 \text{ kg.}$$

where F = weight of scrap (kg.)
X = % O_2 in blast.

No mathematical relation between oxygen content of blast and scale or iron ore charged could be derived because of the limit on such additions imposed by the violence of the reaction. Scale additions exceeding 55 kg. (121 lb.) per ton caused metal to be ejected from the vessel. It was found, however, that 2.8 kg. (6.2 lb.) of steel scrap was equivalent to 1 kg. (2.2 lb.) of mill scale or iron ore in cooling effect.

Since temperatures of the heats were fairly uniform it is concluded that in bottom blowing with increased oxygen in the blast the effect of increased CO_2 formation is not significant and a sensible thermal balance for the operation with enriched oxygen may be deduced with the empirical formulas.

The reduced time of blast with enriched oxygen blast is covered thoroughly and a curve shows the blowing time against the percentage of oxygen in blast. The formula given for this curve is XY = 20.8 where X is the per cent oxygen and Y is the ratio between the blast duration (blowing time) with enriched oxygen and the blast duration with normal air (20.8% O_2). Experimental points follow this curve quite uniformly but fall slightly below the theoretical curve. With 30% oxygen, the blowing time was reduced 23%.

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For ALUMINUM
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Solution heat treating

For FERROUS METALS
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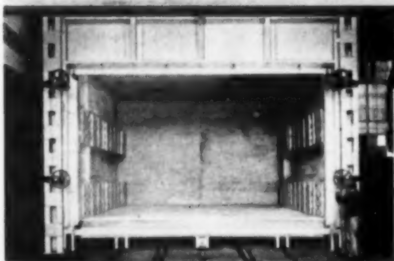
For all heating requirements up to 1350° F. where accurate heat control and uniformity in the work chamber is desired. Car bottom furnaces. Bottom entry quick quench furnace for solution heat treatment of aluminum. Conveyorized furnaces and all other material handling designs.

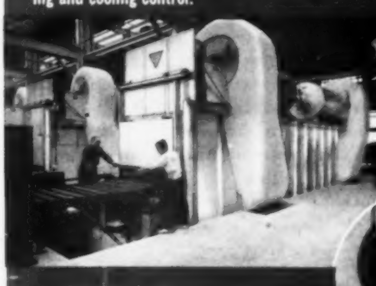
DESPATCH

Laboratory furnace for research and production control.



Despatch Stress Relief Furnace, gas fired car bottom type. Has automatic pre-heating, soaking and cooling control.

Battery of Despatch pot type furnaces heat treating steel parts.



Despatch continuous conveyor furnace for steel heat treating.

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Is the current alloy shortage creating a heat-treating problem for you? Must you accept alloy steels with less chromium, manganese, molybdenum, or vanadium than you originally specified? Then you'll be interested in the performance of Gulf Super-Quench. Because of its dual-quenching power, this outstanding quenching oil helps offset the lower hardenability of today's substitute steels.

Gulf Super-Quench passes through the vapor stage far more quickly than conventional quenching oils. This means that the cooling rate is extremely fast at the outset, an important factor in the depth and uniformity of hardening. In the succeeding stages Gulf Super-Quench has a slow cooling rate, like that of conventional quenching oils, and therefore has the same minimum tendency toward distortion and cracking.

Greater quenching power of Gulf Super-Quench adds up to greater depth of hardening and more uniform hardness! One of the most practical advantages of Gulf Super-Quench is greater uniformity of results on steels of variable hardenability.

For further information on Gulf Super-Quench, call in a Gulf Sales Engineer today. Write, wire, or phone your nearest Gulf office.

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AT 158 TO 284 DEG. F.

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This HASTELLOY alloy C expansion joint is constantly exposed to acetic acid vapors saturated with acetyl chloride and containing small amounts of chloracetic acid. Alloy C is practically unaffected by these corrosive vapors at temperatures of 158 to 284 deg. F. Used at the top of a 24-foot distillation still, the joint is also elastic enough to compensate for the almost half-inch growth of the heated tower.

HASTELLOY alloy C and the other two grades of this nickel-base alloy—alloys B and D—are excellent construction materials for all types of processing equipment that must resist corrosive attack. In addition to their unusual corrosion resistance, alloys B and C have high mechanical strength and are available in both cast and wrought forms. Alloy D is available in cast form only. All three alloys are readily fabricated by most common methods. Fill out the handy coupon below for the whole story on these alloys.

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TECHNICAL TOPICS

WELDING STAINLESS ALLOYS

Norman S. Mott
Chief Chemist and Metallurgist
The Cooper Alloy Foundry Co.

In the welding of stainless alloys, four types of composition have to be taken into consideration -- the hardenable martensitic straight chromium group; the non-hardenable ferritic straight chromium group; the corrosion resisting chromium-nickel group, and the heat resisting chromium-nickel group. These alloy compositions have, in varying degrees, greater thermal expansion and lower thermal conductivity than carbon steels, and in some instances have carbide mannerisms which affect corrosion resistance.

When the torch flame or arc is applied, the metal is heated to a very high temperature only in the area being welded. The heated metal expands and tends to push out in various directions against the colder surrounding metal, producing severe internal stresses. When the heat source is removed, the resultant contraction produces pulling stresses acting between the cooling and the cold metal. If the metal does not have sufficient ductility to stretch and accommodate itself to these great stresses, cracking will result. This is most prevalent in the lower ductility straight chromium grades. By making temperature gradients as gradual as possible, this danger can be minimized.

In the chromium-nickel corrosion resisting alloy types, a form of grain boundary carbide precipitation occurs during welding. To offset the dangers of intergranular corrosion, these carbides must be put into solution by subsequent heat treatment before the welded metal is put into use.

Difficulties which are involved in welding cast stainless steel can be overcome through the use of pre-welding and post-welding thermal treatments as indicated below. Alloys for heat resistance applications usually do not require any thermal treatment after welding.

ALLOY	REMARKS
5% Cr	Preheat to 400° F or over. After welding, cool to not less than 300° F, then heat to 1650° F . . . hold for 1 hour, furnace cool to 1350° F, hold for 2 hours, then air cool.
9% Cr	Preheat to 400° F or over. After welding, cool to not less than 300° F, then heat to 1350° F . . . hold for 2 hours, then air cool.
12% Cr	Preheat to 400° F or over. After welding, cool to not less than 300° F, then heat to 1350° F . . . hold for 4 hours, then air cool.
16% Cr	Preheat to 250-300° F. After welding, cool to 250° F or lower, then heat to 1450° F . . . hold for 4 hours, then air cool.
18% Cr	Preheat to 250-300° F. After welding, cool to 150° F or lower, then heat to 1450° F . . . hold for 4 hours, then air cool.
27% Cr	Preheat to 250° F or over. After welding, heat to 1650° F . . . hold for 2 hours, then rapidly air cool. If distortion is feared, stress-relieve weld for 1 hour at 1350° F followed by air cooling.
18-8S	Preheat not required. After welding, heat at 2000° F for 1 hour, then water quench.
18-8SCb	Preheat not required, nor is post heat. However, after welding, it may be stress-relieved at 1650° F for 2 hours followed by air cooling.
18-8SMo	Preheat not required. After welding, heat at 2000° F for 1 hour, then water quench. Sufficiently ferritic alloys can often be used without post heating.
FA-20	Preheat to 400° F. After welding, cool very slowly, then heat to 2000° F . . . hold for 1 hour and water quench.

Copies of this article reprinted on heavy stock for convenient filing are available on request.

The COOPER ALLOY Foundry Co., Hillside, N. J.

Sinter Layer Formation on Cast Metals*

Castings are often covered with a layer of metal oxides and silicates, in many cases with veins of metal penetrating the layer. This covering is termed a "sinter layer" or "peel". Removal of sinter layers is a serious commercial problem, and some consideration has previously been given to the manner in which these layers form. It was thought that some sinter layers formed by mechanical action. That is, the liquid metal would penetrate the sand pores, melt the sand, and bind this mass together with sand grains to the casting. Other sinter layers were thought to form by chemical action whereby iron oxide would form in the sand pores and react with the quartz to form iron silicate. This compound would then adhere to the casting to form the sinter layer.

Additional work on the problem seemed to be needed since neither of the above mechanisms explained the following important effects observed in commercial iron and steel castings: *(a)* the increase in amount of sinter layer with increase in clay content of the molding mixture; *(b)* the decrease in amount of sinter layer on steel castings produced by a thin layer of quartz on the surface of the mold; *(c)* the difference in strength of adherence of the sinter layer under varying conditions. It was recognized that sinter-layer formation occurs under extremely complicated conditions of changing temperature and gaseous atmosphere, and that it depends on the dimensions and form of the casting for a given alloy and mold mixture. Therefore, the simplest possible conditions were chosen for testing, and the strength of adhesion of a solid substance (sinter layer) to the metal was measured by observing the degree to which the substance was wet by the metal.

The test procedure consisted in placing 1-g. cylinders of cast iron on horizontal plates of each of three different "mold" materials, pure graphite, pressed SiO_2 powder, and pressed Al_2O_3 powder. The cast iron cylinders were heated and caused to melt. In all tests the cylinder began to melt at the edges, and sometimes it "boiled up" while a

(Continued on p. 124)

*Abstract of "Formation of a Sinter Layer on Cast Metals", by Yu. A. Klyachko and L. L. Kunin, *Zhurnal Prikladnoi Khimii*, Vol. 22, 1949, p. 707-715.

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Sinter Layer Formation on Cast Metals

(Continued from p. 122)

white cloud formed around it. When burning out of these components had ended, the cylinder transformed to a drop covered with a slag layer. A new phase formed at the boundary between the SiO_2 and the cast iron (fayalite in this test), and between the Al_2O_3 and the cast iron (in this instance a mixture of fayalite and iron oxides; slags for both were also of this composition).

From measurements of the angle of wetting made on the solidified drops, the adherence of the solid substance to the cast iron was estimated. The angle on graphite was about 120°, on SiO_2 102°, and on Al_2O_3 75°. Thus, the new phase that formed on Al_2O_3 had the strongest adherence to cast iron.

On the basis of these results, a new theory of the formation of sinter layers was proposed. It was suggested that the adhesion of an intermediate phase to the metal casting and to the mold material is determined by the closeness of matching of the corresponding ionic lattices. It was shown that this view of the nature of the process explains the three effects listed at the beginning of the paper. This new theory will be useful, not only in avoiding undesirable sinter layer formation, but also in promoting the growth of nonmetallic layers for such purposes as corrosion protection.

A. G. GUY

Stress Relief in Magnesium Castings*

A METHOD is described by which the degree of stress relief resulting from any given annealing treatment may conveniently be assessed. The method is capable of general application to stress-relief annealing problems and has been used to establish suitable conditions of treatment for the magnesium casting alloys AZ91, A8, Z5Z and MCZ.

To obtain his data, the author applies to magnesium alloys a technique similar to that developed by Hallett and Wing (*Foundry Trade Journal*, Vol. 87, 1949, p. 177) for

(Continued on p. 126)

*Abstract of "Stress Relief and Allied Problems in Magnesium Alloy Castings", by R. J. M. Payne, *Journal of the Institute of Metals*, Vol. 78, October 1950, p. 147-168.

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Stress Relief in Magnesium Castings

(Continued from p. 124)

studying stress-relief problems in cast iron. Rings (approximately 3½ in. o.d., 2¾ in. i.d. and 1 in. deep) were cast in green-sand molds under careful control. These test rings were slit on a radial plane and gage marks were scribed on either side of the slit. The pieces were then stressed by inserting an oversized steel wedge in the slit.

Under the conditions used, the author admits that the magnitude of the stresses developed was not accurately known, "but this was not a cause for any deep concern, as subsequent tests showed that residual stresses (following relief annealing) were largely independent of initial stresses". These rings were annealed at various times and temperatures, the steel wedges were removed, and the springback of the ring was taken as an indication of the remanent stress.

Stresses in magnesium-base alloys Elektron AZ91 (9.7% Al, 0.5% Zn, 0.2% Mn) and A8 (8.3% Al, 0.6% Zn, 0.2% Mn) were reduced by annealing at 250, 300, and 330° C. The relief occurred rapidly at first but at a diminishing rate thereafter. The relaxation proceeded until stress was reduced to a limiting value, which was lower the higher the annealing temperature. The drop in residual stress occurred relatively more rapidly at the higher temperatures and relatedly the limiting value of stress was reached sooner at the higher temperatures. Ninety-five per cent of the residual stresses were removed in 2 hr. at 330° C., whereas only 87% of the stress was removed in 4 hr. at 250° C. The mechanical properties of the alloys were not detrimentally affected by these anneals.

The magnesium-base alloy Elektron Z5Z (4.5% Zn and 0.7% Zr) was interesting since this is a heat treated alloy. It was found, however, that the 2-hr. heat at 330° C. — of all the coincidences! — develops the full mechanical properties of the alloy, reduces 97.5% of the residual stresses, and allows "setting" of the castings (bringing warped castings to shape by heating in a dimensionally accurate jig).

Stress relief cannot be effectively accomplished in MCZ (3% mischmetal, 0.6% Zr). The particular virtue of this alloy is its creep resistance and this is destroyed when

(Continued on p. 128)

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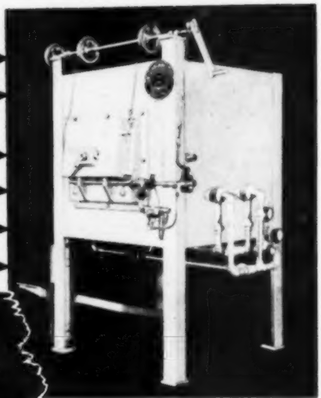

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Stress Relief in Magnesium Castings

(Continued from p. 126)

the alloy is heated at 300 or 330° C. Heating to 250° C. does not destroy the alloy's creep resistance but it has precious little effect on stress relief too.

The author concludes that the best treatment for MCZ is *(a)* leave it in the as-cast condition where stresses are low, *(b)* effect a little stress relief at 250° C. for 10 hr., *(c)* air cool from 570° C. (a solution treatment) with or without a heat treatment at 200° C. The author cautions that the last alternative may not be a panacea: "Further experience is required to show whether either the solution treatment or the double-stage heat treatment with the additional trouble, expense, and risk of distortion involved, could justifiably be applied to castings for stress removal purposes."

W. M. BALDWIN, JR.

Use of O_2-CO_2 Blast in the Basic Converter*

THE LARGE NUMBER of recent articles in European literature in the last few years on the use of oxygen in the basic bessemer process indicates a determined effort to reduce the nitrogen content of this type of steel. Since 39% of European steel is produced in the basic bessemer process, the importance of these investigations is readily evident.

Austrians are using air enriched to 25% O_2 at Linz, and several German plants are also operating on a similar basis. The French are studying the use of oxygen enrichment of the blast, the Belgians are experimenting with mixtures of oxygen and steam, and this Swedish paper describes the interesting use of a 50% O_2, 50% CO_2 blast in the last stages of decarbonization and dephosphorization of the high phosphorus hot metal. The main object of these efforts is to produce a basic bessemer steel containing a maximum of 0.006% N_2 from a hot metal having 0.006% N_2 and to melt increased amounts of steel scrap in the converter.

This investigation was con-

(Continued on p. 146)

*Abstract of "The Use of Oxygen-Carbon Dioxide Instead of Air in the Final Stage of the Basic Bessemer Process", by Bo Kalling, Folke Johansson and Lennart Lindskog, *Journal*, Iron and Steel Institute, Vol. 168, August 1951, p. 337-343.

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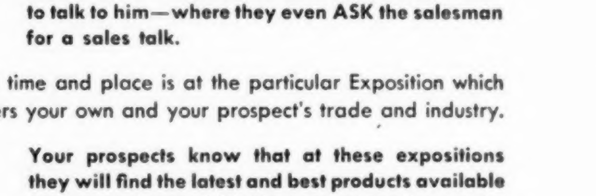

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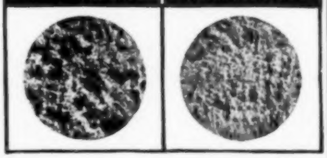

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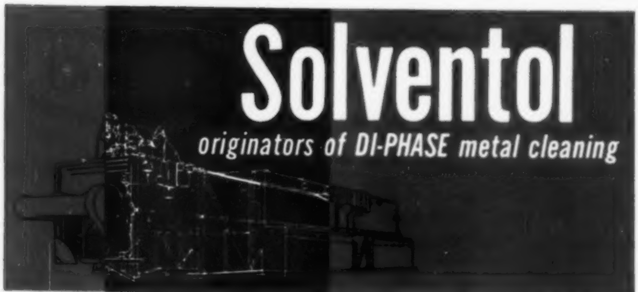

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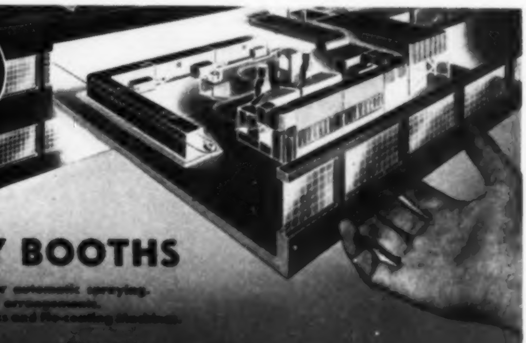

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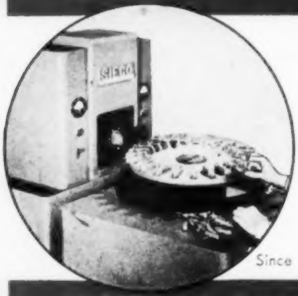

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Annealing • Hardening

Sizes: Standard—2,4,10,25 KVA; Custom—to 100 KVA

Fast · Powerful · Reliable

Challenge Comparison—Value • Quality • Price • Design • Appearance

Free Trial Run of Your Sample Parts

Complete data, application photos, prices, delivery in New illustrated Catalog. Write on your company letterhead.

Since 1930... Pioneers in Megacycle Heating

THOMAS REGISTER

SHERMAN *Industrial Electronics Company*
New York Area Office and Plant
505 Washington Ave., Belleville 9, N. J.

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CIRC-AIR

HEAT TREATING FURNACES

for Every Heat Treating Process

★

CONTROLLED ATMOSPHERES

★

DIRECT FIRED

★

CIRC-AIR DRAW FURNACES

★

CIRC-AIR NICARB
(CARBONITRIDING)

Specially Engineered for Your Particular Needs

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GAS • OIL • ELECTRIC

INDUSTRIAL HEATING EQUIPMENT COMPANY
[illegible] • Detroit 7, Mich.

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Upton

... offers

THE MOST ADVANCED SALT BATH FURNACES FOR ....

Batch Type Work	*Conveyorized Type Work*

Upton Electric Furnace Co.
16808 Hamilton Avenue • Detroit, Michigan
Phone, Diamond 1-2520

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ALWAYS SPECIFY THE BEST

Morrison ENGINEERED

FURNACES	OVENS
ANNEALING	CORE BAKING
HARDENING	PAINT BAKING
TEMPERING	ROD BAKING
GALVANIZING	MOLD DRYING
NORMALIZING	LITHOGRAPHING
HEAT TREATING	ANNEALING
DRAWING & BRAZING	ARMATURE BAKING

Morrison ENGINEERING CORP
2222 FAIRHILL RD.
CLEVELAND 6, OHIO

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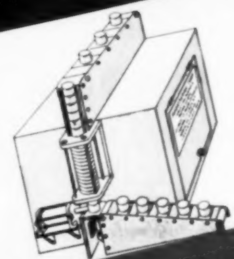
MAGNETHERMIC

Low Frequency (60-cycle) Induction Heating



the production advantage you have been seeking

• Practically every extrusion press in the last three years has been equipped with a Magnethermic 60-cycle billet heater. Now, Magnethermic furnaces have been adapted for brass, copper, magnesium and steel for annealing, forging, extrusion and other primary and secondary heating, both ferrous and nonferrous.

- ACCURATELY CONTROLLED HEAT
- UNIFORM HEAT THROUGHOUT PIECE
- NO WARM-UP TIME
- OPERATES ON STANDARD POWER SUPPLY
- COOL OPERATION
- AUTOMATIC LOADING AND UNLOADING
- MINIMUM FLOOR SPACE
- SIZES UP TO 20,000 LBS.
- EASY INSTALLATION—CONNECT POWER LEADS AND COOLING WATER, THAT'S ALL.

Prompt Answer to Your Inquiry

WRITE FOR ILLUSTRATED BOOKLET

60-CYCLE INDUCTION HEATING
MAGNETHERMIC corporation
ANDREWS AVE. • YOUNGSTOWN 1, OHIO

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HEAT RESISTANT CASTINGS

* BUFFALO
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Ellicott Square

CINCINNATI
Pearson Browne
1st Nat'l Bank Bldg.

CLEVELAND
Alloy Sales & Service
Chas. Plant, Jr.
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DETROIT
Gehringer & Forsyth
16151 James Couzens Hwy.

HOUSTON
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2221 Telephone Rd.

LONGMEADOW, MASS.
B. G. Constantine
Control Engineering Co.
51 Converse St.

MILWAUKEE
Ed. P. Lindergren
3748 W. Greenfield Ave.

NEW YORK CITY
R. B. Steele
254 W. 31st St.

PHILADELPHIA
Towle & Son
18 W. Chelton Ave. Bldg.

PITTSBURGH
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Whenever you have a heating problem that involves heat resistant parts, take advantage of Standard's long experience in producing alloy castings engineered to your specific need. Conveyors, roller hearths, trays, containers, fixtures radiant tube assemblies—and many more designs for a wide variety of applications are available.

* Consult the engineering representative nearest you—or write for the interesting 4-page Bulletin No. 1.

STANDARD ALLOY CO., INC.
1679 COLLAMER ROAD · CLEVELAND 10, OHIO

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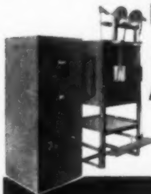

PERECO
ELECTRIC
FURNACES AND KILNS

PERENY EQUIPMENT COLUMBUS OHIO

Clean heat, accurately controlled. Wide choice of models for research, pilot plant, and production. Standard units for temperatures from 450° to 3000° F., or special research equipment up to 5000° F., to meet *your* needs.

WRITE FOR DETAILS TODAY
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Dept. Q, 893 Chambers Rd., Columbus 12, Ohio, U.S.A.
EXPORT DEPT The Inland Export Co., Inc. Greer Bldg., New Castle, Pa., U.S.A.

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Non-Case

Anti-Carburizing Paint

Applied to any part of steel prior to carburizing, Non-Case protects that specific part from the absorption of carbon. Here is an invaluable coating that prevents carburization, or hardening, of certain spots or sections of steel parts. Easy to use, Non-Case is available in *quart or gallon cans.*

Write for Descriptive Literature

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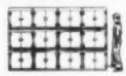
PORTABLE ELECTRIC OVENS

FOR THE METAL WORKING INDUSTRY

Standard Models for Every Special Need

LOW COST



Model HT-2

Max. Temperature 1000° F.

Approx. 4 cu.ft. working space.

220 Volt — 1 phase. Thermostat controlled. Can be used in groups or banks.

Standard models 225° F and up.

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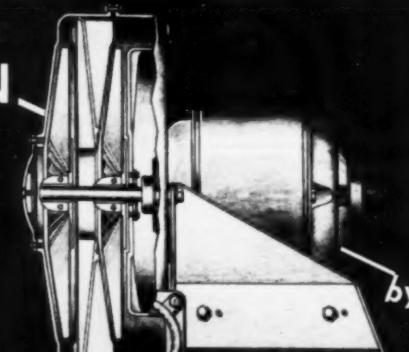
DESIGN



Turbo Blowers

by **North American**
Manufacturing Company
GAS OR OIL COMBUSTION EQUIPMENT
CLEVELAND 5, OHIO

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FOR ALLOY *CONSERVATION USE

KASENIT

SURFACE HARDENING COMPOUNDS

- NON POISONOUS
- NON EXPLOSIVE
- NON INFLAMMABLE

*Kasenit saves you money by simply and inexpensively providing controlled surface hardness on plain alloy and carbon steel parts. No scaling or warping. Try **KASENIT** now.

1-lb. Trial Size **$2.00**

KASENIT COMPANY
799 Greenwich St., Dept. MP
New York 14, N. Y.
Established 1912

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INSTRUMENTS AND CONTROL FOR HEAT TREATING FURNACES

A complete summary of Hays products applicable to processes such as annealing, brazing and calorizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages, and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO_2 recorders are covered.

Send for Bulletin 49-750

THE HAYS CORPORATION
MICHIGAN CITY 26, INDIANA

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Control Temperatures More Closely

REDUCE COST • SAVE TIME

This Catalog of Improved Pyrometer Supplies shows you how!

Get your FREE Copy Today!

★ **Thermocouples** ★ **Protection Tubes**
★ **Thermocouple Wire** ★ **Lead Wire**
★ **Insulators** ★ **Terminal Heads**

ARKLAY S. RICHARDS CO., Inc.
NEWTON HIGHLANDS 61, MASS.

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Serving the

HEAT TREATING INDUSTRY

Since 1930

- **Complete Service on Control Equipment**
- **Thermocouples**
- **Protection Tubes**
- **Charts and Lead Wire**

THE CLEVELAND ELECTRIC LABORATORIES COMPANY

1988 E. 66 St. Cleveland 3, Ohio

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FREE

The Quenzine Story

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . . .

Aldridge Industrial Oils, Inc.
3401 W. 140th St., Cleveland 11, Ohio

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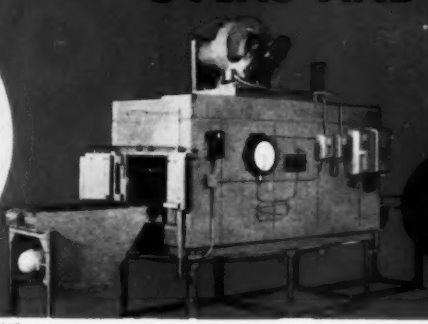
COMPLETELY AUTOMATIC HEAT TREATING OVENS AND FURNACES

Typical of many automatic and time-operated heating ovens and furnaces designed by Carl-Mayer, the pictured illustration conserves valuable man-hours. Conveyor and batch-type furnaces up to 2000 F., using gas, oil, or power, can be designed and built to meet your heating and processing problems.



CARL-MAYER CORPORATION
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CLEVELAND, OHIO

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Diversified Heat Treating Facilities for . . .

STEEL · ALUMINUM · MAGNESIUM

FORGINGS · CASTINGS · TOOLS AND PARTS

Carbonitriding
Controlled Atmosphere
Cyanide and Neutral Baths
Liquid, Gas and Pack Carburizing
Induction Heating

Pit Type Convection Furnaces
Large Car Bottom Furnaces
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Solution Heat Treatment
Hardening
Tempering
Normalizing
Annealing

Grit Blasting
Shot Blasting
Shot Peening

Our management, production and sales staff are all metallurgically trained. Their combined experience is available for complete heat treating counsel without obligation.

Send for Free Booklet of Complete Facilities

Pearson INDUSTRIAL STEEL TREATING CO.

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42nd YEAR

A VINCENT PROCESS For

EVERY HEAT TREATING NEED

300-TON DAILY CAPACITY

MODERN FACILITIES

VINCENT STEEL PROCESS CO.
2424 Bellevue Ave. • Detroit 7, Mich.

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HEAT TREAT at it's *Best!*

COMPLETE SERVICE including —
BRIGHT HARDENING OF STAINLESS STEELS ... STEAM TREATING HIGH-SPEED CUTTING TOOLS ... HARDENING ... TEMPERING ... CLEANING.

Our Metallurgical Engineers can help with your metal treating problems.

COMMERCIAL STEEL TREATING CORP.
6100 Tireman Detroit 4, Mich.
TYler 6-6086

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YOUR COMMERCIAL **HEAT TREATER** IN DETROIT

OFFERS FACILITIES FOR:

1. **ALUMINUM** - CAP. 500,000# PER MO.
2. **MINUTE PARTS** TO 2-TON DIES
3. **BRIGHT HARDENING** OF STAINLESS STEEL

ALL TYPES OF HEAT TREATING CAN BE DONE BY . . .

STANDARD STEEL TREATING CO.
3467 LOVETT AVE. DETROIT, MICH.

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HEAT TREATING

OF METAL PA...

Lindberg Steel Treating Company is ideally equipped to serve you in any phase of the heat treating field.

- Located in four major industrial areas.
- Equipped to perform every process — from the most conventional to the latest and most difficult techniques.
- More than 25 years of experience in processing almost every conceivable type of metal part.
- Trained and experienced metallurgical engineers available for consultation at any time — just call or write.

Write or call for your copy of the illustrated booklet "Surface Hardening of Stainless Steel."

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St. Louis 15, Missouri

222 N. Laflin Street Chicago 7, Illinois

620 Buffalo Road Rochester 11, New York

LINDBERG STEEL TREATING CO.

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STEEL TREATING

• FLAME HARDENING
• CARBURIZING & HARDENING
• LIQUID • PACK • GAS
• SHOT BLASTING • ANNEALING
• TENSILE TESTING • NORMALIZING

HEAT TREATING & STRAIGHTENING OF BARS UP TO 22' LENGTHS

MEMBER AMERICAN SOCIETY FOR METALS

HEnderson 1-3837

THE W. S. BIDLE CO.

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DON'T WAIT... COOPERATE!

The U.S. Needs Your Steel Scrap, Now

Nonferrous Scrap Is Needed Too

BRIGHT HARDENING and ANNEALING of STAINLESS STEEL

HEAT TREATMENT of ELECTRICAL ALLOYS

ATMOSPHERE CONTROLLED HEAT TREATING

and STANDARD OPERATIONS

DREVER CO.

HEAT TREATING DIVISION

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Heat Treating OF METALS

Flame Hardening	Stress Relieving
Induction Hardening	Normalizing
Chapmanizing	★ Gas, Pack or Liquid Carburizing
Nitriding	Annealing
Cyaniding	★ Silver-Finish Hardening of Dies or Tools
Cadmium, Tin or Copper Plating	★ Roto-Blasting
Anodizing or Alrocking of Aluminum	Silver or Copper Brazing

PITTSBURGH COMMERCIAL HEAT TREATING CO.

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Boron Steel

Just off the press . . . . a timely collection of eight articles on boron steel, reprinted from METAL PROGRESS.

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American Society for Metals

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Our Services: Electronic Induction Hardening, Flame Hardening, Heat Treating, Bar Stock Treating and Straightening (mill lengths and sizes), Annealing, Stress Relieving, Normalizing, Pack, Gas, or Liquid Carburizing, Nitriding, Speed Nitriding, Aerocasing, Chapmanizing, Cyaniding, Dry Cyaniding, Sand Blasting, Tensile and Bend Tests.

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COMPLETE

METALS TESTING
SERVICE

- CHEMICAL
- PHYSICAL
- SPECTROGRAPHIC
- RADIOGRAPHIC
- METALLOGRAPHIC

★ SPECIAL STUDIES WITH RADIOACTIVE TRACERS

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ESTABLISHED 1880

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NEW YORK • BOSTON • PHILADELPHIA • MEMPHIS • DALLAS
HOBOKEN • PROVIDENCE • CHICAGO • LOS ANGELES • DENVER

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MERIAM
MANOMETERS

U-TYPE • WELL TYPE • DUAL TUBE

FLOW METERS
DRAFT GAUGES

For measuring pressure, vacuum and differential pressure of liquids and gases.
Also a complete line of accessories.

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◀ *U-TYPE MANOMETER*

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Headquarters for

NON-DESTRUCTIVE TESTING
and
MEASURING INSTRUMENTS

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ULTRASONIC & MAGNETIC INSPECTION EQUIPMENT
Crack & Defect Locators
Metal Sorters
Ultrasonic Thickness Gages

ELECTRONIC MICROMETERS
For production measurement of precision components to within 0.000020 in.

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ENGLEWOOD, N. J.

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Solve

INSPECTION DEMAGNETIZING SORTING PROBLEMS *with*

MAGNETIC ANALYSIS EQUIPMENT

Electronic Equipment for non-destructive production inspection of steel bars and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

This Equipment is now employed by more than 40 Steel Mills and many Steel Fabricators.

MAGNETIC ANALYSIS DEMAGNETIZERS

Electrical Equipment for efficient production demagnetizing of steel bars and tubing. When used with Magnetic Analysis Equipment inspection and demagnetizing can be done in a single operation.

MAGNETIC ANALYSIS COMPARATORS

Electronic Instruments for production sorting of ferrous and non-ferrous materials and parts for variations in composition and physical properties.

ALSO MAGNETISM DETECTORS

Inexpensive pocket meters for indicating magnetism in ferrous materials and parts.

For information write "THE TEST TELLS"

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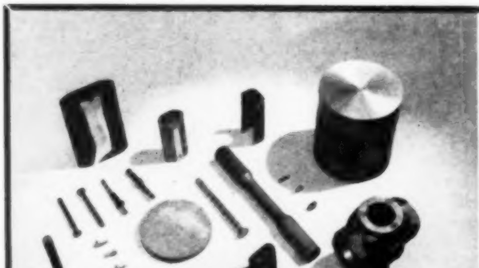

IF CONTROL OF THESE PARTS IS YOUR PROBLEM . . . SPECTROSCOPY IS THE ANSWER!

Undivided responsibility for complete installation of all Spectrographic equipment.

NATIONAL SPECTROGRAPHIC LABORATORIES, INC.

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FLASH-O-LENS Lights and Magnifies

METAL SURFACES FOR FAST, ACCURATE INSPECTION

Another FLASH-O-LENS at work—this time at Eastman Kodak Company!

You *too* can cut down inspection time and improve product quality by using this simple, handy, low-cost instrument that *spotlights* the work and *magnifies* it at the same time . . . the FLASH-O-LENS!

Just put a FLASH-O-LENS on the part you're inspecting. Built-in bulb puts light *on* the field of vision—keeps it *out* of user's eyes. Accurately ground lenses give sharply detailed enlargement. Result: time-and-eye-saving inspection, surer maintenance of quality standards.

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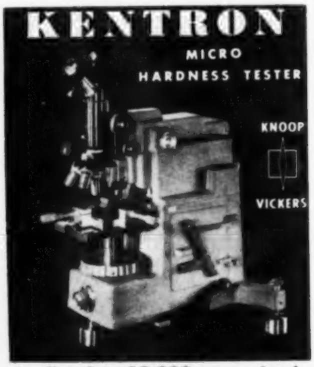

Applies 1 to 10,000 gram loads

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KENT CLIFF LABORATORIES
PEEKSKILL NEW YORK

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LABORATORY FURNACES

You tell Boder what you need

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719-723 Liberty Ave.
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BODER SCIENTIFIC PITTSBURGH

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Use the **BARBER COLMAN** ***Impressor***

on ALUMINUM COPPER BRASS BRONZE and PLASTICS

for Fast and Efficient
HARDNESS TESTING

Works on the principle of forcing a hardened, spring-loaded steel point into the surface, the amount of penetration registering instantly on a dial indicator to give a dependable measure of hardness. Operator simply places Impressor on surface and presses down firmly. Can be used in any position, even against edges or ends of pieces when stacked. Requires little effort, ideal for women inspectors. Strongly built for durability and consistent accuracy. Thousands in use. *Comes in velvet-lined, fitted wood case with extra point and full maintenance instructions.* Write for Bulletin F-1689-1.

BARBER-COLMAN COMPANY
1225 ROCK STREET • ROCKFORD, ILLINOIS

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FAST ACTION

IN TENSILE AND BRINELL TESTING

Whether your testing problems involve the tensile strength or Brinell hardness of metals or component parts, Detroit Testing equipment will speed your operations. In fact, on any tests involving metals, consult Detroit Testing — or write for informative literature.

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ARDCOR TUBING ROLLS

***PRODUCTION PROVEN — 30% More Footage!**

These Tubing Rolls, made of ARDCORLOY* — a special alloy steel, were designed and manufactured by ARDCOR for one of America's leading Welded Tube Manufacturers (name on request).

What are YOUR Roll Forming Requirements?

ARDCOR ROLLER DIES • ROLL FORMING MACHINERY • CUT-OFF MACHINES

American ROLLER DIE CORPORATION
20680 St. Clair Avenue • Cleveland 17, Ohio

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Use . . .
Hangsterfer's
LUBRICANTS
for . . . Increased Production
Less Scrap
Longer Die Life

Doing the most difficult jobs for the major metalworking plants throughout the United States and Europe.

HANGSTERFER'S LABORATORIES, INC.
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Darwin

PRK-33 ◀ Air Hardening, Non Deforming, 13% Cr, 3% Co

NEOR ◀ Oil Hardening, Non Deforming, 13% Cr, 2% C

MINEOR ◀ Air Hardening, Non Deforming, 5% Cr, 1% Mo

DARWIN & MILNER INC.
Highest Grade Tool Steels
2345 St. Clair Avenue
Cleveland 14, Ohio

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TOOL STEEL

NATIONALLY KNOWN BRANDS

BELOW MILL PRICES

- High Speed: T-1 to T-15, M-1 to M-56
- High Carbon—High Chrome
- Oil Hardening
- Air Hardening
- Water Hardening
- Hot and Cold Work-Die Steel
- Fast Finishing Steels

COMPLETE WAREHOUSE FACILITIES

MILL GUARANTEED

RELIABLE STEEL CO.

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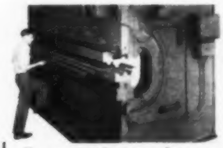
STEELWELD BENDING PRESSES

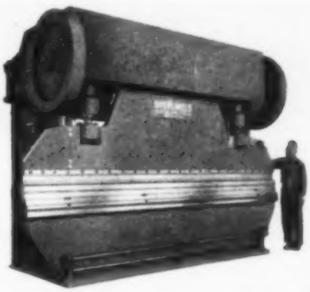


Corrugating and any straight-line production bending can be done to hairline accuracy.

Conical sections are quickly formed with standard bending dies by use of the ram-tapering mechanism.

Large holes can be punched singly. Smaller holes can be punched 25 to 150 at a time.

Steelweld Presses for bending, forming, blanking, drawing and multiple-punching operations. Complete line for all size metal to 1¼" x 20'-0". Write for free copy of catalog No. 2010.



Steelwelds have heavy duty one-piece welded frames that stay rigid for life. Machinery is top quality throughout and easy to maintain.

THE CLEVELAND CRANE & ENGINEERING CO.
5941 East 281st Street • Wickliffe, Ohio

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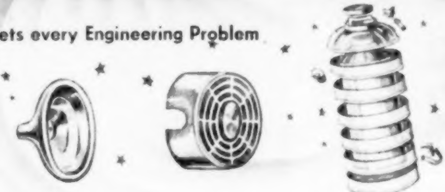

METAL Spinning
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C. A. DAHLIN meets every Engineering Problem

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..any metal you name - *Investigate the C. A Dahlin facilities for dependable service and quality workmanship.*
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USE OUR
HOEGANAES
SPONGE IRON POWDER
for
Powder Metallurgy
Fabrication
and other
Metallurgical Purposes

EKSTRAND & THOLAND, Inc.
441 Lexington Avenue
New York 17, N. Y.

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CONSERVE METALS!!
with 3 DIMENSIONAL
Rigidized Metals

You'll get:
- REDUCED WEIGHT
- ADDED STRENGTH
- IMPACT RESISTANCE
- SURFACE PROTECTION
- REDUCED MAINTENANCE COSTS
- MORE SQUARE FEET PER POUND OF METAL

WRITE FOR FREE CONSERVATION HANDBOOK

Rigidized Metals Corporation
682 OHIO STREET, BUFFALO 3, N. Y.
Offices in Principal Cities in U.S.A. & Canada

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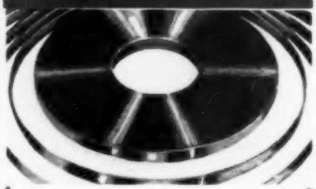
For Stainless Steels, Spring Steels, Cold Finished Steels, Drill Rods, Cold Rolled Strip, Cold Rolled Sheets, Aluminum Sheets and Bars



Stainless Steel in strip, sheet, bars, tubing and accessories.

Cold Finished Steels in all standard shapes and carbon analyses.

Spring Steels in Blue Tempered and Polished Coils, Cold Rolled Annealed Coils and Straight Lengths in 1070 and 1095 Carbon grades and Hot Rolled SAE 1095 and 9255 Bars. Wires include Polished Music Spring Wire, Black Oil Tempered Spring Wire.

Cold Rolled Sheets — Cold Rolled Strip in coils and straight lengths, all tempers, slit, sheared and round edge.

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Aluminum Sheets in coils and straight lengths in all alloys —**Aluminum Bars and Rods.**

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INC.
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LFA

"SILVERCOTE"®
BERYLLIUM COPPER
Hardenable & Tempered
ALSO OTHER NON-FERROUS
WIRES
for
- ★ SPRINGS
- ★ FORMS
- ★ SPECIAL PURPOSES

LITTLE FALLS ALLOYS
INCORPORATED
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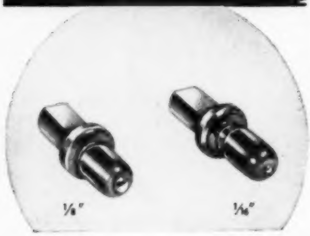

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Use of O_2-CO_2 Blast in the Basic Converter

(Continued from p. 128)

ducted in a 14-ton bottom-blown basic bessemer at the Domnarfuet Iron Works in Sweden. The hot metal contained 3.30 C, 0.30 Si, 0.70 Mn, 1.80 P, 0.05 S and 0.006% N_2. In ordinary practice using air blast, the blows lasted 13 min. and produced steel containing 0.02 C, 0.00 Si, 0.17 Mn, 0.04 P, 0.03 S and 0.012% N_2. The charge in the converter consisted of about 15 tons of pig iron, about 1700 lb. of scrap and about 17 tons of lime.

Twelve special blows were run in which the converter was blown with normal air blast until the drop of the carbon flame (to about 0.2% C) and then a blast of 53% O_2, 47% CO_2, was applied. This gas mixture was arrived at by calculations as having heating effects similar to normal air. The average time of these special blows was 9 min. 40 sec. for the air blast plus 1 min. 35 sec. for the O_2-CO_2 blast, or a total time of 11 min. 15 sec. The gas consumption is given as 636 cu.ft. of oxygen and 530 cu.ft. of CO_2 per ton; bath temperature at tapping was about 2900° F. The average nitrogen content of the O_2-CO_2 blows was 0.0055% before tapping and 0.0065% in the finished steel.

The marked increase of nitrogen in teeming is attributed to a high nitrogen content (0.95% N_2) of the anthracite coal added to the ladle. A complete discussion of the heat balance, CO_2 content of exhaust gases, lining life, carbon and phosphorus content of the bath, metal yield, and iron content of the slag under the two conditions of blowing is given in the paper.

The authors concluded that the use of the CO_2-O_2 blast after the drop of the carbon flame is an effective means of controlling the nitrogen content of the steel without changing equipment, charging practice or blowing procedure. The gas mixture of 50% O_2 yields the same end temperature as normal air blowing. By using oxygen-enriched air in the normal air blowing stage and the O_2-CO_2 mixture for the dephosphorizing stage, heats with 0.003% N_2 may be produced. The price of the gas mixture is estimated at 2 shillings per thousand cubic feet or a total cost per blow, using 1200 cu.ft. of O_2-CO_2 gas mixture per ton of steel, is $1.2 \times 2 = 2.4$ shillings, or about 29 cents per short ton at the present rate of exchange. E. C. WRIGHT

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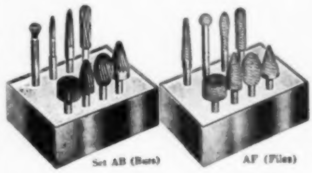

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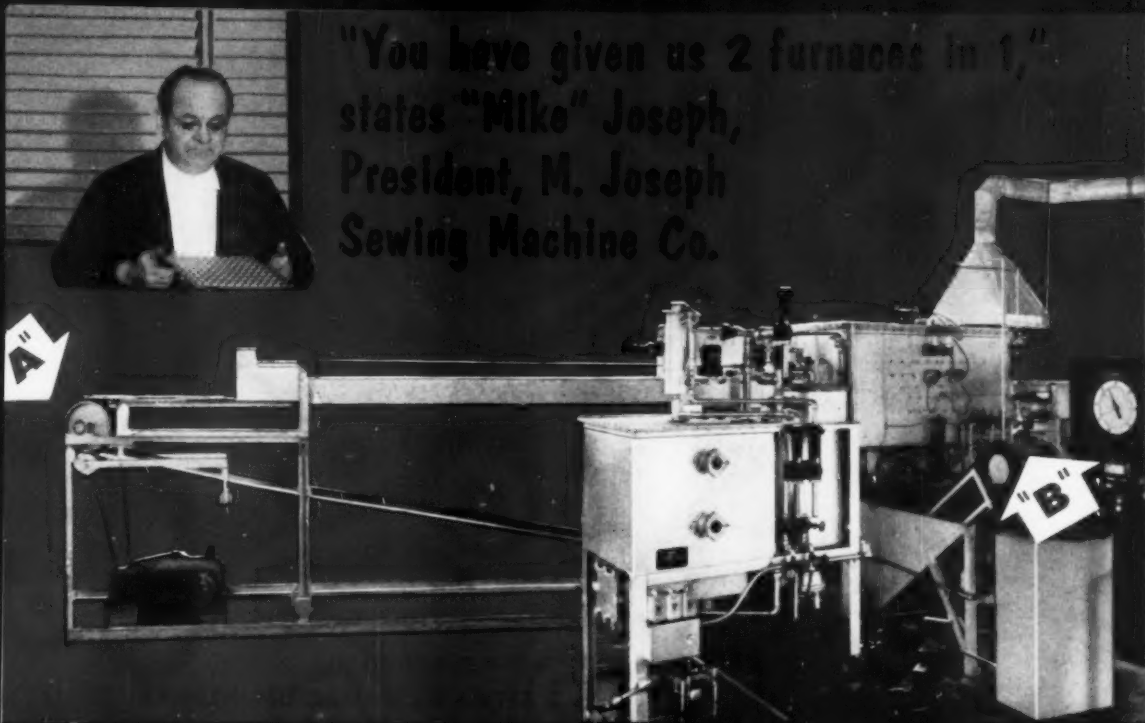

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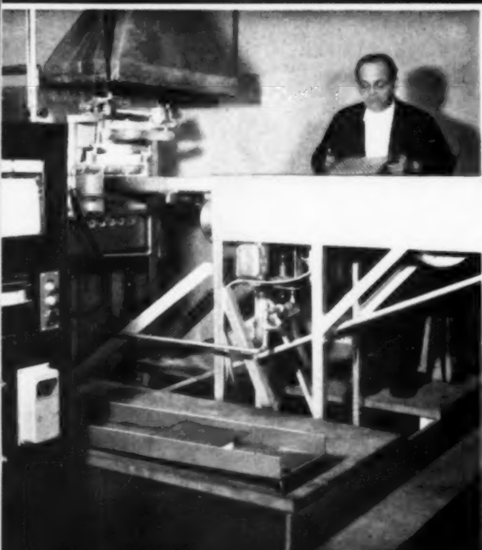

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Vasco Supreme — Form cutters produced 9,156 ball races per grind from S.A.E. 52100 steel compared to 3,055 pieces per grind from competing cobalt high speed steel.

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Nested Electrode Welding*

The "nested electrode" consists of two or more filler metal rods held adjacent to each other in parallel positions but insulated from each other except at one end where they are gripped by the holder or otherwise joined to a common source of current. Standard commercial types of covered electrode can be used satisfactorily with a special electrode holder. In this study commercial electrodes of 1/8-in. diameter were used.

The nested electrode offers parallel paths for the current flow and, since the current will follow the path of least resistance, the welding arc switches from one core wire to the other as the arcing core wire burns off and the other core wire end approaches the base metal making a shorter gap. The speed with which the arc switches from one to the other core wire may be controlled by arc length and amount of current used. The shape of the weld puddle may be controlled by the pattern of arrangement of the core wires.

The particular pattern of core wire arrangement in any specific case is indicated by a number designation. With three core wires arranged in a line perpendicular to the direction of welding, this is designated as Arrangement No. 3; arranged in a line parallel to the direction of welding, this is designated as Arrangement No. 1-1-1. With three core wires nested in the form of an equilateral triangle, the arrangement is designated either as No. 1-2 or No. 2-1, depending upon whether a single core wire or a pair of core wires is leading in the direction of travel. Various arrangements, including six core wires in an arrangement designated as No. 2-2-2, were used. Electrodes of the AWS Series E6010, E6013, E6016 and E6020 were tried in the study.

To determine the effect of electrode core wire arrangement on the shape of the weld puddle, bead welds were laid on 1/4 x 2-in. strips of hot rolled mild steel. The electrode arrangements No. 2, 3 and 4 showed progressive widening of the weld bead and the depth of penetration was shallow. E6010 electrodes produced a weld deposit that was susceptible to centerline cracking. Beads were flat and contoured smoothly into the parent metal surface and all deposits were sound when a conventional arc-length manipulation was used.

With a "modified fire cracker" manipulation, in which a contact arc is used with the electrode held at an angle to the parent metal surface and no forward movement is provided by the welder, the weld beads were somewhat porous and had a high flat contour coming down sharply to the plate surface at the edges. The weld puddle exhibited rapid gas evolution, and centerline cracking occurred in some instances.

Using the E6016 electrode in arrangements No. 2 and No. 3, with conventional arc-length manipulation, weld beads were produced having a contour similar to those with the E6010 electrode. There was no evidence of gas evolution from the weld puddle which was shallower than that obtained with the E6010 electrode.

The "modified fire cracker" arc technique with the E6016 electrode produced a high flat bead such as obtained with the E6010 electrode

(Continued on p. 152)

*Abstract of "Nested Electrodes for Metal-Arc Welding", by William A. Snyder, *Welding Research Supplement*, November 1951, p. 557s-564s.

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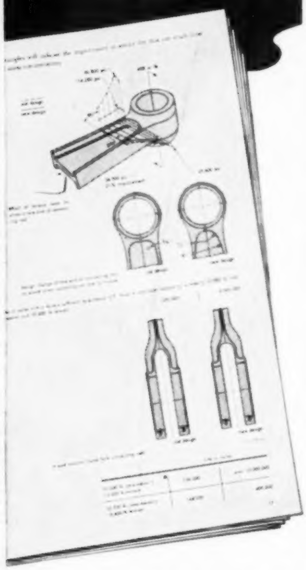

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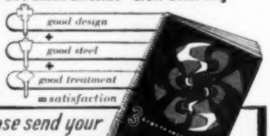

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MOLY

MP-3 F21

Nested Electrode Welding

(Continued from p. 150)

but without the porosity. Metal transfer was uniform and the arc was very stable. A tendency to undercut may be eliminated by placing core wires behind the first row, that is, by using arrangement No. 3-1 instead of No. 4.

Metal deposit may be varied from a wide flat bead to a narrow high bead, without materially changing the rate of metal deposition, by the pattern in which the electrodes are nested. The E6010 electrode does not lend itself well to nested operation and the smoothest and most uniform weld beads were obtained with nested E6020 electrodes. In general, the penetration obtained with the nested electrode was less than would be had with a single electrode of equal cross section.

Slag-free deposits are obtained with current settings suitable for the nesting arrangement used. To operate smoothly, the nest must maintain a puddle extending under all of the electrodes in the nest. Average current density used varied from 4000 to 8000 amp. per sq.in. of nested electrode cross section. Actual densities often exceeded 24,000 amp. per sq.in.

The author concludes that, "The stitching arc that may be obtained from arrangement No. 1-1 with a low current setting should prove to be of interest for welding stainless steels. The stitching arc was used with arrangement No. 2 to deposit a hard-surface overlay on cast-steel test plates. Due to reduced dilution of the weld metal, the hardness of the deposit was as high as would normally be expected on the second pass. The ability to produce a large weld without penetrating deeply should be useful in welding steel castings."

W. L. Warner

Grain Refinement of Aluminum Alloys*

This is a report of the results of experiments made by the British Nonferrous Metals Research Assoc. in continuation of the investigation of the grain refinement of aluminum. In a report previously issued

(Continued on p. 154)

*Abstract of "The Grain Refinement of Aluminum Alloy Castings by Additions of Titanium and Boron", by A. Cibula, *Journal*, Institute of Metals, Vol. 80, September 1951, p. 1-16.

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163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
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213	363	800	1350	1900
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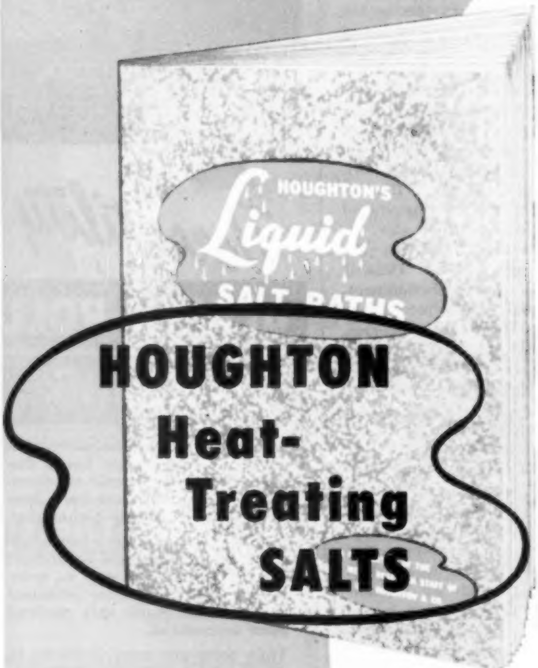

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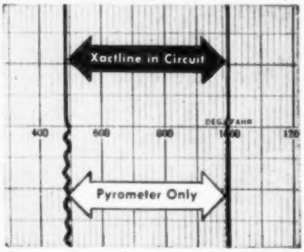
Put XACTLINE in the control circuit. XACTLINE anticipates the temperature changes—before they occur. And too, it nullifies the varying amounts of thermal lag, residual heat, and mechanical lag—producing a short on-off cycle resulting in "Straight-Line" temperature control. This performance is possible because there is no dependence upon mechanical parts—XACTLINE operates electrically.



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Grain Refinement of Aluminum Alloys

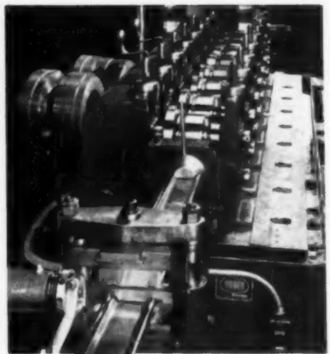
(Continued from p. 152)

by this organization (*Journal*, Institute of Metals, Vol. 76, December 1949, p. 321-360) it was concluded that the grain refining effect of titanium is due to the presence of titanium carbide crystals in the aluminum, and in the present report this explanation is accepted as proved, in spite of a contrary conclusion reached by Crossley and Mondolfo of this country (*Journal of Metals*, American Institute of Mining and Metallurgical Engineers, Vol. 3, December 1951, p. 1143-1148). Their apparent proof that the refinement is due to $TiAl_3$ produced by a peritectic reaction was, of course, not available when the British paper was written. Thus, if the real cause of the phenomenon is sought, the reader is left to choose between the two theories, each confirmed to the satisfaction of the respective author. Maybe both are partly correct.

Materials of high purity were used in most of the experiments reported in this paper, but some tests were also made with commercial alloys. Considerable reliance was placed on a centrifugal method of separating heavier solid phases from the melts. In a preliminary series of experiments, it was established fairly firmly, although by circumstantial evidence, that when boron alone is used for grain refinement, the nucleating agent is aluminum boride, AlB_2. For example, when an alloy containing 0.04% boron was centrifuged at a temperature at which the boride was solid and the aluminum liquid, and subsequently solidified, the grain size was coarse and the edge of the sample where the boride collected gave X-ray diffraction lines compatible with the presence of AlB_2. When centrifuged at a temperature above that of solution of the compound, the grain size after solidification was fine.

Attempts to increase the effectiveness of titanium-bearing "hardener alloys" by raising their carbon content or by using directly very fine titanium carbide powder pelletized with aluminum were not very successful. The difficulty was ascribed to a lack of wetting of the carbon and carbide by molten aluminum. This was avoided by the use of titanium boride through adding separate aluminum-titanium and aluminum-boron hardener alloys; these additions combined gave very

(Continued on p. 158)



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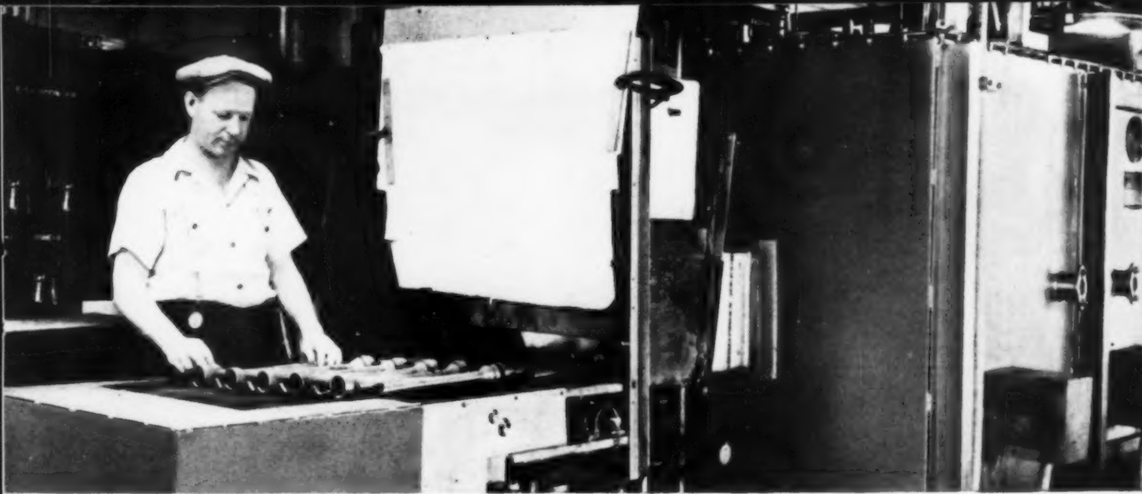

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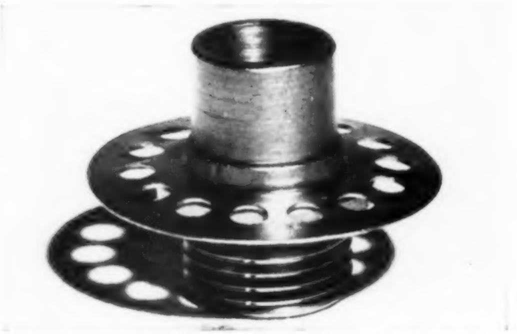

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GENERAL ELECTRIC

Grain Refinement of Aluminum Alloys

(Continued from p. 154)

fine grain size with less titanium and less boron than are effective if used alone. Only 0.001% boron was found to be sufficient in a melt containing 0.14% titanium which was made coarse grained by bubbling nitrogen through it to remove the titanium carbide nuclei. X-ray examination of nuclei, concentrated by centrifuging a melt, indicated that they might be titanium boride with either excess titanium or aluminum boride in solution.

In a commercial alloy containing 4.9% copper, cast at 1470° F., adequately refined grain size was attained with only 0.03% titanium and 0.01% boron. This represents a considerable saving in the amount of titanium required if used alone, and the refinement was more permanent on remelting. Another advantage in using boron with titanium is that the grain refining nuclei do not then settle out so rapidly with the heavier primary crystals from the upper part of a casting, and grain size is thus more uniform in all parts of the casting than it is when titanium alone is used. When boron is used alone, considerably more than 0.01% is generally required and there is then danger of a reaction of the melt with the sand mold, giving subsurface porosity.

Attempts to find a better way to add the required boron and titanium in practice than by means of the two hardener alloys separately were not very successful. In hardener alloys intended to contain titanium and as little as 0.5% boron, the boron segregated badly, since the solubility of titanium boride is so very low in aluminum; no products of consistent composition and effectiveness were made. The use of salt mixtures such as potassium titanofluoride with potassium borofluoride was fairly successful, especially when added at temperatures as high as 1400° F., but generally the results were not as good as when hardener alloys were used. The preferred boron hardener was made from potassium borofluoride at 2000° F.

Effective grain refinement of a 4.9% copper-aluminum alloy cast at 1470° F. was attained with 0.01% boron and 0.01 to 0.02% of either columbium, vanadium, or titanium, but the latter was slightly better.

G. F. Comstock

The Recrystallization of Martensite*

Specimens of a chromium-manganese steel, KhG (1.44 C, 0.62 Mn, 1.29 Cr, 0.22 Si), were oil quenched from 1200° C. (2190° F.) and then cooled in liquid nitrogen to obtain a coarse intragrain texture. (The texture referred to is that of the decomposition product within a given austenite grain; the orientation relationship of the original austenite grain to the decomposition product results in the latter having a texture within a given prior austenite grain.) The specimens were then reheated to various temperatures at a rate of 100° C. (180° F.) per sec. and subsequently water-quenched.

Oscillograph records of the heating of the specimens showed a definite break at 1370° F. The specimen that was heated to 1630° F. and water quenched had a Rockwell hardness of C-67 and a coarse

(Continued on p. 160)

*Abstract of "Recrystallization of Austenite Dependent on Internal Cold Work", by K. A. Malyshev, V. D. Sandovskii, and B. G. Sazonov, *Doklady Akademii Nauk SSSR*, Vol. 76, 1951, p. 61-64.

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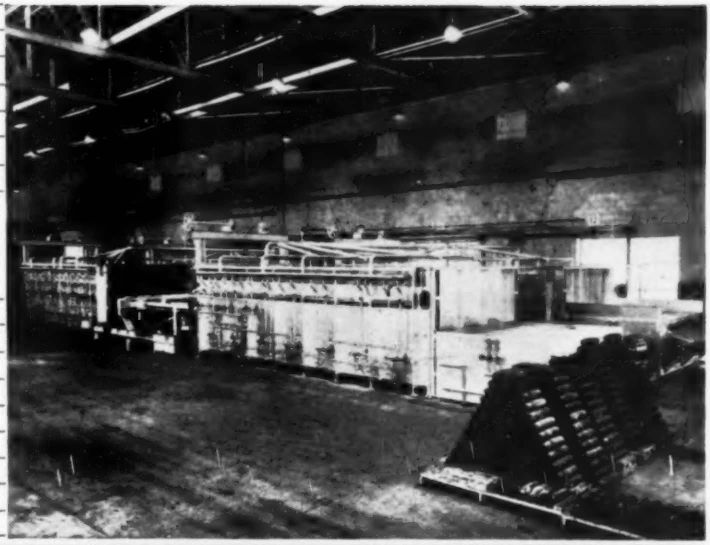

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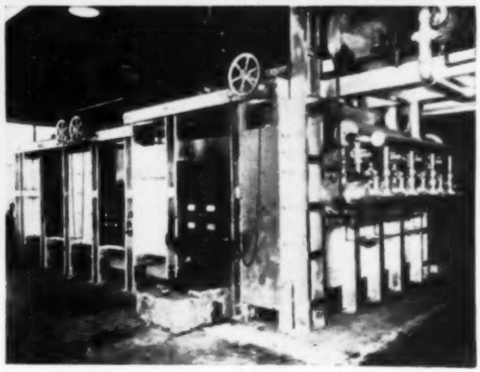

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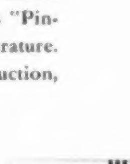

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The Recrystallization of Martensite

(Continued from p. 158)

fracture grain size; the one heated to 1790° F. had a hardness of C-49 and a finer fracture grain size.

From these data it was concluded that the alpha-to-gamma transformation occurs at 745° C. (1370° F.) during the rapid heating. Also, the intragrain texture corresponding to the prior coarse austenite grains is completely reproduced on a second quenching from 1370° F., or even from 1630° F. This behavior is said to support a previous conclusion that the gamma phase formed from the alpha phase during heating bears an orientation relationship to the alpha.

The fine-grained fracture of the specimen quenched from 1790° F. is a result of recrystallization of the austenite grains formed by the alpha-to-gamma transformation. The cause of this recrystallization is the internal cold working of the new austenite grains. The internal cold working is produced by volume changes accompanying the alpha-to-gamma transformation and by rapid heating above the Ac_1 point. During heating to higher temperatures the new grains grow in normal fashion and cause coarsening of the fracture grain size of the quenched specimens.

Metallographic examination of a steel having similar composition but alloyed with nickel failed to reveal any new grains of austenite in the positions of the martensite needles. This sample was heated to a temperature slightly above that at which the alpha-to-gamma transformation was completed.

Another specimen that was heated to a somewhat higher temperature had small austenite grains in the positions of martensite needles; these grains were larger in specimens heated to still higher temperatures. In other areas of the former martensite needles, which were subjected to less cold working during the alpha-to-gamma transformation, no recrystallized grains were observed. These areas were believed to be filled with austenite produced by the phase transformation. During further heating, the recrystallized austenite grains grew into these areas and into the residual austenite. Thus, the changes that occur on heating steel above the critical temperature are complex and include phase transformation, recrystallization and grain growth. A. G. GUY

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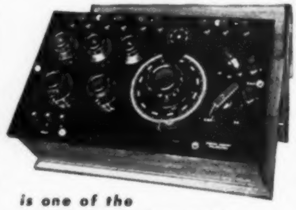

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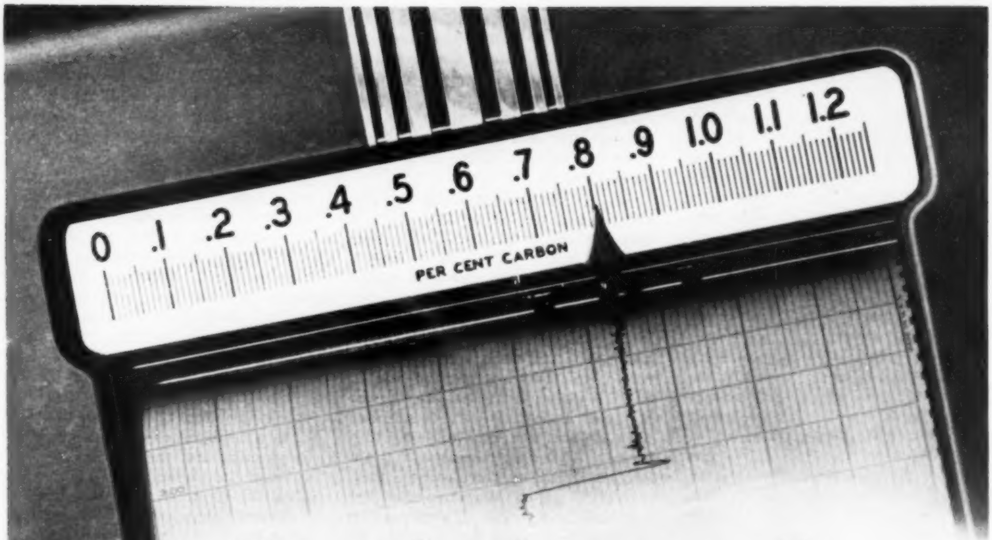

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Ninety-nine out of 100 metallurgists and heat-treaters have not yet had a chance to see a continuous instrument record of the carbon in a furnace's carburizing gas. And probably not 99 out of 10,000 production men have seen such a sight.

But neither group is going to be unfamiliar with this advance for much longer, because this valuable information is now as easy to get as a temperature record. It comes from a Micromax Carbon Recorder, which is part of the brand new L&N Microcarb Control.

Already several dozen plants have ordered Microcarb equipment. Here and there a present user is letting his friends drop in for a peek. So, the Carbon Record will soon be pretty generally known to men who look for the modern way to cut carburizing costs or improve carburized parts.

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The full Microcarb story will be mailed on request. Address either our nearest office, or 4927 Stenton Ave., Philadelphia 44, Pa.

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Zr and Ti Substitutions for Manganese in Steel*

THIS PAPER presents a laboratory study of the substitution of zirconium and titanium for manganese in the control of sulphur in fully deoxidized steels. The effects of these additions on the hot shortness or forging properties of the laboratory heats is described and conclusions reached as to the possibility of zirconium and titanium as substitutes for manganese in times of emergency.

A review of prior literature by the author establishes the strong influence of zirconium and titanium as desulphurizers; Field and Becket reported that steels containing 0.15% Mn and 0.2 to 0.3% sulphur were readily forged and rolled whenever the Zr:S ratio exceeded 1.41:1. This ratio corresponds to the formula ZrS_2. Similar work on titanium additions indicate the formation of a stable TiS compound which gives freedom from hot shortness in steels. In addition to the formation of stable sulphides, whose melting point is above 2200° F., the normal forging temperature, zirconium and titanium are also known to be much more potent deoxidizing agents than manganese.

The paper describes the melting, rolling and testing of 72 heats. A base analysis of 0.18 to 0.23% carbon, 0.18 to 0.23% silicon and 0.025% phosphorus (maximum) was melted in 75-lb. charges in a silica crucible in the induction furnace and teemed into 35-lb. ingots of octagonal shape about 3⅝ in. thick. Ingots were rolled to 2 x 2-in. sections on a 10-in. rolling mill and the rolling behavior reported. These sections were then sawed longitudinally into four 1-in. square sections 3¼ in. long. These samples were then turned to ⅝-in. diameter for the hot shortness tests. Twenty-seven heats with various Mn:S ratios; 24 heats with various (Mn + Zr):S ratios and 21 heats with various $(Mn + T_6)$:S ratios were tested.

All of the base analysis melts were treated with a 0.3% Al addition (6 lb. per ton) prior to the final manganese, zirconium or titanium additions. The carbon and silicon content of the base analysis was obtained by additions of high-purity pig iron (whatever that may be) and ferrosilicon following the heavy deoxidation with aluminum. No mention is made of the fact that aluminum has desulphurizing effects, and, since over 50% of all steel melted is of the semikilled or rimming type, that such completely deoxidized heats would not yield any information as to the use of zirconium or titanium additions to this kind of steel. High silicon of the base analysis also eliminates the "open" steels from consideration.

Hot shortness of the steels was measured by means of the hot impact test devised by Taylor of Armco Steel Co. In this test the specimens were first heated to 2300° F. in a Globar tube furnace, soaked for 5 min., and then placed on the anvil of the impact testing machine. A falling hammer equipped with a V-shaped nose produced a transverse bending impact upon striking the specimen. The test pieces heated to 2300° F. were held on the anvil until the testing temperature, measured by an optical pyrometer, was reached. Each heat was tested over a temperature range of 1600 to 2400° F. and the hot shortness de-

(Continued on p. 164)

*Abstract of "Behavior of Zirconium and Titanium in Steels With Particular Emphasis on the Conservation of Manganese", by William W. Austin, Jr., a paper read before the Birmingham, Ala., Regional Meeting of the American Iron and Steel Institute, September 1951.

for

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Grain growth inhibitors in metallurgically determined amounts are included . . . in addition to boron . . . among the elements composing Grainal alloys.

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termined by the appearance of the bent or broken specimen; about 12 samples per heat were tested.

The summarized results indicate that a ratio of 7.5:1 Mn:S is necessary for the heats containing only manganese; a ratio of 5:1 for (Mn + Zr):S is necessary in zirconium heats; and a ratio of 5.5 to 6:1 (Mn + Ti):S in the titanium heats was necessary to prevent hot shortness. These conclusions are based on sulphur ranges of 0.03 to 0.06% in present-day steel specifications and a residual manganese of about 0.15% which is typical of most basic openhearth heats at tapping time. Thus zirconium and titanium are satisfactory substitutes for manganese in killed steels.

The efficiency of the zirconium addition is given as an average of 33% and for titanium as 66.5%. This is for heats previously fully killed with aluminum before the alloy addition. It would be interesting to have efficiency data for these alloy additions without any Al addition. The author states that the cost of zirconium is six times greater than manganese and twelve times greater than titanium, and that these materials are only of interest when no manganese would be available. E. C. Wright

Plating Room Controls for Pollution Abatement*

Primary purpose of this booklet is to show how stream pollution can be minimized by reducing waste discharges. However, it should also have special appeal for managers of metal-finishing plants, since it also tells how to cut operating costs.

Metal-finishing establishments can further pollution abatement by:

1. Reduction in dragout and all other plating materials.
2. Purification of contaminated processing baths for re-use.
3. Exchange or sales of processing baths that cannot be purified.
4. Installation of waste treatment facilities.

Dragout losses can be reduced by the following measures: *(a)* Rinse effectively; *(b)* prevent leaks and losses; *(c)* salvage solutions for further use (do not discard them); *(d)* sell or exchange baths that cannot be purified.

Rinsing can be made effective by the use of save-rinse tanks, use of saved rinse water to reduce the amount of fresh water used, concentrating saved rinse water, minimizing dragin of water from the rinse tanks preceding the processing tank by draining the work as completely as possible, and the use of drip boards. Also clean racks, fog sprays, uniform racking and correct rinse-tank design are important in the control of this problem.

Leaks and losses may be minimized by: Periodic inspection; installing piping and pumps in the open; filling tanks from above the surface; float valves to prevent overflows; stand-by storage tanks to save baths if they should spring leaks; the use of adsorbents to reclaim spills instead of flushing.

Lastly, the manual recommends salvage of solutions for further use rather than to discard them. Purification procedures are established and in use for most of the processing baths, such as: activated-carbon treatments; low current-density purification; high pH treatments; oxidation; low-temperature crystallization; settling and decantation; filtration; precipitation. The possibility of selling or exchanging the condemned solutions to another industry should also be investigated.

*Abstract of "Plating Room Controls for Pollution Abatement", a reference publication compiled by the Metal Finishing Industry Action Committee, Ohio River Valley, Water Sanitation Commission, 414 Walnut St., Cincinnati. Price 50¢.

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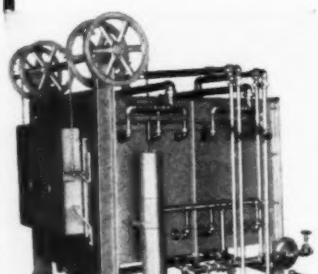

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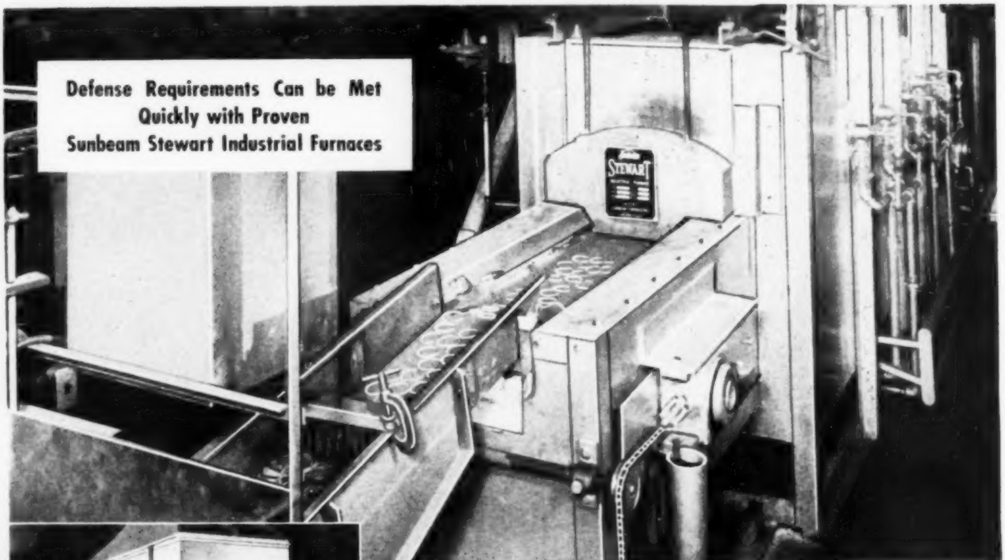

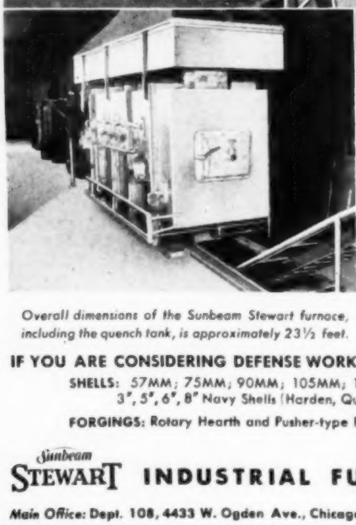

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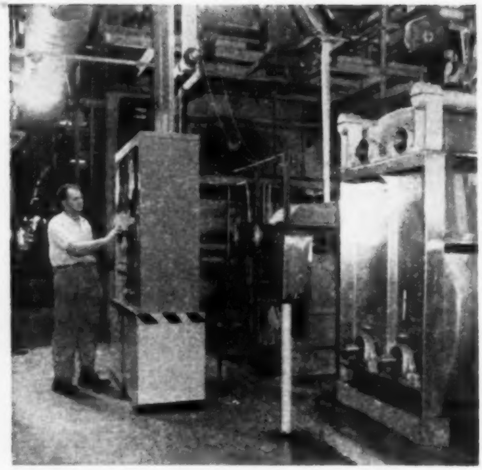
INCONEL® • INCONEL "X"® • INCOLOY® • NIMONICS

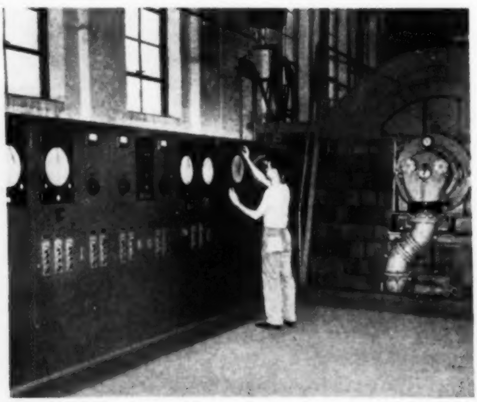
HOT DIP *tin house in large eastern steel mill uses* **ElectroniK** *instruments to control metal and palm oil temperatures . . . in adjacent departments, the same instruments control huge electrolytic tin lines, insuring quality tinplate and minimum use of the strategic metal.*



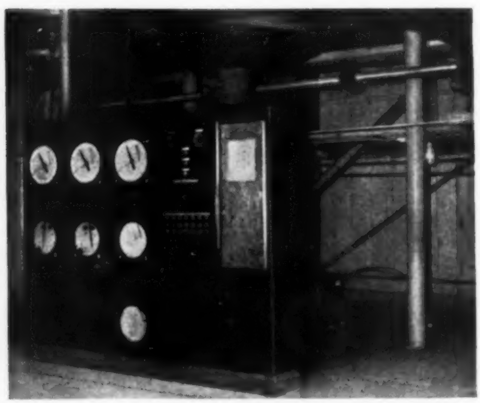
COORDINATION *of speeds, temperatures, pressures, flows and other variables . . . through modern instrumentation . . . makes possible the stabilization of continuous textile bleaching, and results in greater overall production in such a modern installation as this.*

For all of industry . . . *especially*

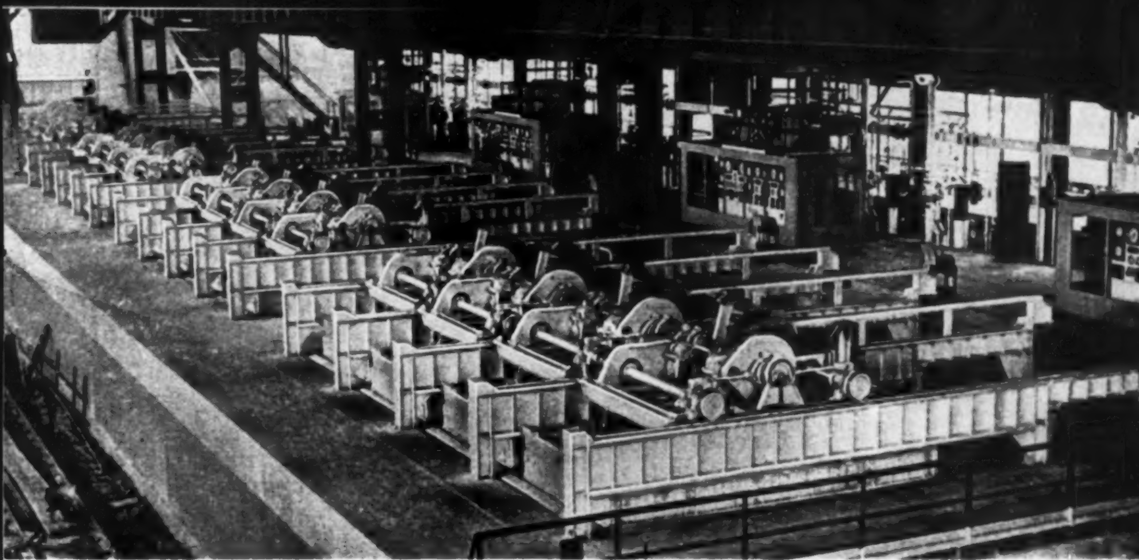
Instruments



ONE MAN BLEACH PLANT, *with the best equipment and controls, produces 130 tons of bleached pulp per day. The plant runs so smoothly that the operator also has time to make hourly tests on bleach liquor and bleached pulp.*



CITRUS CONCENTRATORS *at Pasco Packing Company plant turn out 1250 gallons of high quality concentrate per hour. One man supervises operations . . . aided by Honeywell automatic control system which regulates raw juice flow, heat input, and density of finished product.*



BATTERY OF SOAKING PITS *handles mass production of treated ingots, with the help of modern instruments . . . used to maintain pit temperature, bring ingots to proper heat, and insure uniformity. They automatically compensate for load changes, shut off fuel when pits are open, fire again when pits are closed.*

for the metals industry

speed production

FROM HUGE sprawling plants to back-yard shops, the great and growing metals industries are ever ready to meet the multiplied demands of a national economy thirsty for more metal and more metal products. And tops on the list of production tools are the instruments and controls that coordinate and stabilize such critical variables as temperature, pressure, flow and pH.

Modern metal producing and processing couldn't approach the production records now established . . . only to be bettered tomorrow . . . without the aid of industrial instrumentation. The scattered machinery, of tremendous size and unparalleled complexity . . . plus the ever stricter quality specifications . . . demand continuous precision and accuracy available only from instruments and controls which can keep pace with process requirements.

Brown instruments and controls, of course, have been playing a vital role in such production operations for many years . . . and, just as in research and development, will continue to meet the demands of new techniques and new equipment.

Our local representative will welcome the opportunity to discuss your instrumentation requirements . . . for any operation. Call him in today, he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Penna.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls

H
HONEYWELL

● *Important Reference Data*

Write for a copy of new brochure, "Tomorrow Is Today"... for a brief description of the manifold contributions of instruments to industrial processing.

What's the lining life of your
high frequency induction furnaces
melting nickel-chrome steel alloys?

Get more heats with rammed linings of

Taylor Zircon

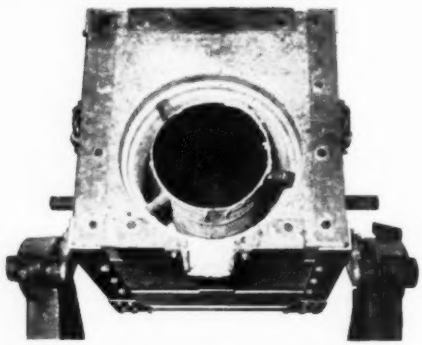
Many foundries have standardized on Taylor Zircon No. 717 grog-type Ramming Mix for lining Ajax-Northrup, Allis-Chalmers and other types of high-frequency furnaces melting nickel, stainless steel and similar high nickel-chrome alloys. High softening point, low thermal conductivity, high di-electric strength, freedom from shrinkage make Taylor Zircon an excellent refractory for this service.

FACTS . . .

- Average life of linings made of Taylor Zircon No. 717* Ramming Mix is 20 to 30% longer than that of linings rammed of magnesia, magnesia-alumina spinel and or sillimanite or mullite when melting high nickel alloys.
- A foundry operating four 650 lb. Allis-Chalmers high frequency furnaces obtained 117 heats on a No. 717 rammed lining melting pure nickel and nickel-bronze alloys.
- A foundry melting 97.5% nickel in 650 lb. Ajax-Northrup obtained 80 heats on Taylor Zircon before patching was required.

A complete line of TASIL (converted mullite), TAMUL (synthetic mullite) and TAYCOR (corundum base) Ramming Mixes and Patches are also offered for varying service conditions. Detailed information contained in Bulletin 315—just off the press. Write for your copy.

** Shipped either WET or DRY—specify on your order.*



Installing Taylor Zircon No. 717 (Wet) Ramming Mix in 300 lb. Ajax-Northrup induction furnace. Before ramming the lining, Taylor Sillimanite (TASIL) No. 101 Patch is used for sealing the primary coil. After drying, Taylor Zircon is rammed in place and No. 101 Patch is used to seal the top and for forming the pouring spout.

Photo at top of page shows the interior of a 1000 lb. Allis-Chalmers furnace lined with Taylor Zircon at end of pour.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

The CHAS. TAYLOR SONS Co.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U.S.A.

if paper were steel . . .

Since controls on the distribution of steel were first imposed in September of 1950, Inland, while adhering to a policy of strict observance of these regulations, has done everything possible to reduce the inevitable hardships to our customers that a controlled steel economy brings with it.

One way we have tried to be helpful: as soon as they are issued, we have carefully studied each of the regulations affecting steel users and have promptly mailed the more important ones, together with our own "boiled down" summaries, to each of our customers.

This job keeps two Inland men hopping and the data sent out to date makes an imposing array as you can see.

We don't like controls on steel production and distribution but, when national security demands them, we'll do our best, within their provisions, to make life as painless as possible for regular Inland steel users.

INLAND STEEL COMPANY

38 SOUTH DEARBORN STREET • CHICAGO 3, ILLINOIS

Sales Offices: Chicago • Davenport • Detroit • Indianapolis • Kansas City • Milwaukee • New York • St. Louis • St. Paul

Principal Products: Sheets, Strip, Tin Mill Products, Bars, Plates, Structural Shapes, Sheet Piling, Reinforcing Bars, Pig Iron, Rails and Track Accessories.

"You may have to stand outside!"

REMEMBER Aesop's fable of the camel and his master--how the kind master allowed the shivering beast to put into the tent first his head, next his shoulders, then his forelegs!

And then the camel said, "Master, I think I ought to come wholly inside," and crowded in. Immediately he said, "There is hardly room for us both, so I think it would be better for you to stand outside so I can turn around and lie down." And without further ado, the camel kicked the man out and took the entire tent.

Men have heard this story for 2,500 years--repeatedly have seen how it illustrates what happens when one man or group of men gain power over others. Men saw it happen in Italy and Germany when Mussolini and Hitler took over. Men saw it happen in Russia.

Even here in America a similar trend is evident. Powerful influences overlook no opportunity, through political manipulation, central controls and bureaucratic regulations, to intrude more and more in our private lives. The situation demands continual, alert watchfulness by all citizens who believe in individual liberty and freedom, to prevent this camel of big government from creeping further into the tent. Before we realize it, "we, the people," the master, may find ourselves "standing outside." In America it is government, which is the servant of the people.

YOUR SCRAP IS NEEDED — YOUNGSTOWN

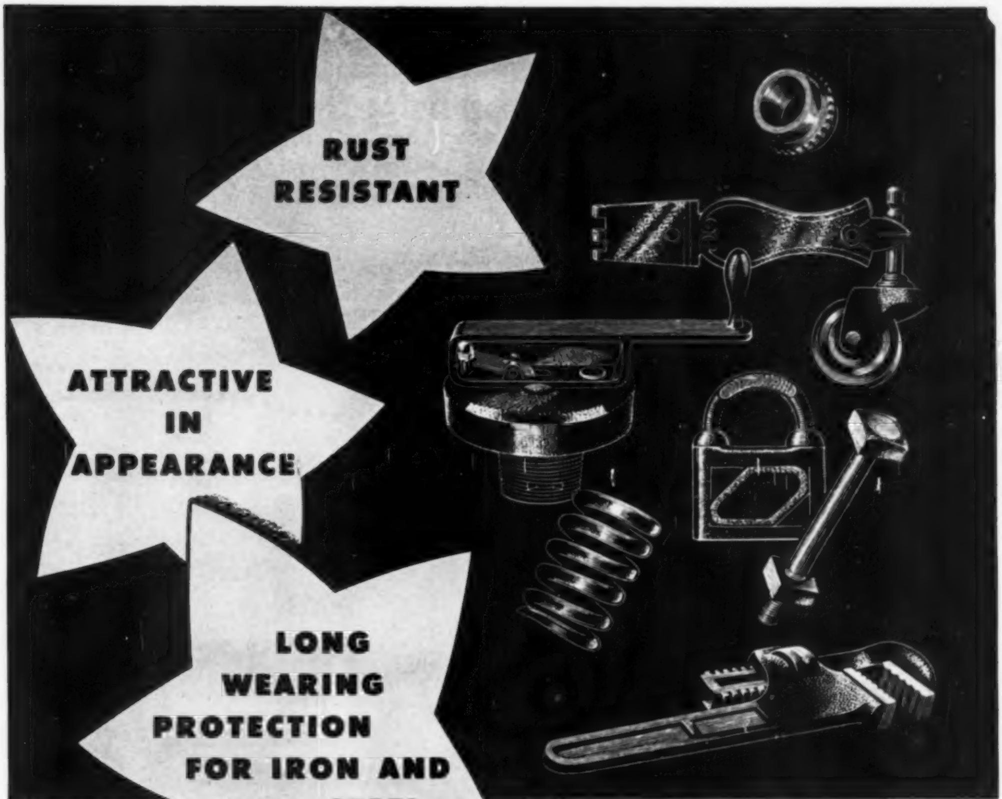
The Youngstown Sheet and Tube Company

General Offices--Youngstown 1, Ohio

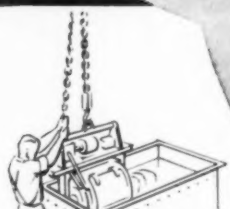
Export Offices--500 Fifth Avenue, New York

MANUFACTURERS OF CARBON ALLOY AND YOLOY STEELS

The steel industry is using all its resources to produce more steel, but it needs your help and needs it now. Turn in your scrap, through your regular sources, at the earliest possible moment



— PARCO COMPOUND



Parco Compound, constantly improved over the past third of a century, now offers greatest efficiency and economy in the protection of iron and steel against rust and corrosion.

In addition to rust resistance, Parco Compound adds greatly to the attractive appearance of the treated parts. When it is combined with stains or oils, a very dark satin finish is produced. Treated metal may be waxed, or may be painted with excellent results.

While efficiency and flexibility has increased, cost is still extremely low. Treatment with Parco Compound is quick, simple, uniform, completely dependable. The only limitation on size of parts treated is the size of the processing tanks.

Parco Compound meets government specifications for military use, and is replacing cadmium and zinc in many civilian applications.

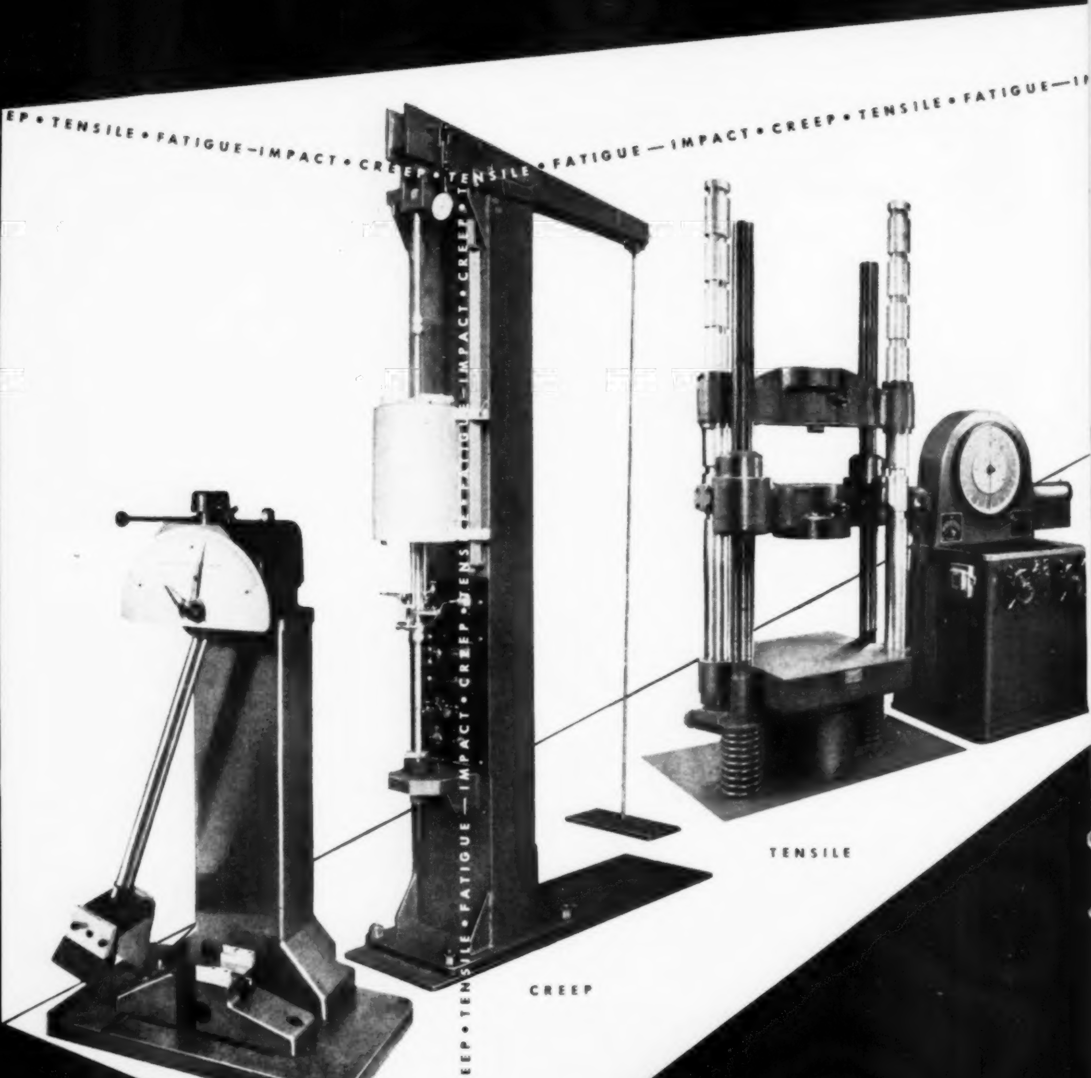
*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

PARKER

PARKER RUST PROOF COMPANY
2216 E. Milwaukee Ave.
Detroit 11, Michigan

BONDERITE—corrosion resistant paint base • BONDERITE and BONDERLUBE—aids in cold forming of metals • PARCO COMPOUND—rust resistant • PARCO LUBRITE—wear resistant for friction surfaces

...*for* LOWEST LOADS —
LOW TEMPERATURES —
STATIC —



HIGHEST LOADS
HIGH TEMPERATURES
DYNAMIC

BALDWIN

Basic Testing Package

BALDWIN-LIMA-HAMILTON

Philadelphia 42, Pa. *Offices in Principal Cities*
In Canada: Peacock Bros., Ltd., Montreal, Quebec

5 groups of specialists in research, development and manufacture of better testing equipment

- Extensometers, Stress Strain Recorders and Accessories—*Washington, D. C.*
- Precision Machining, Fabrication, Assembly of Heavy Components—*Eddystone, Pa.*
- Dynamic Testing Devices—*Greenwich, Connecticut*
- Weighing Systems (Hydraulic)—*New Canaan, Connecticut*
- Weighing Systems (Electronic)—*Cambridge, Massachusetts*

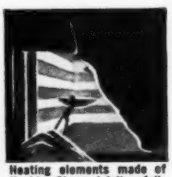
How many SPARKS in a Spark Plug?

Surprising, the confidence that people have in spark plugs. No one stops to question how many "sparks" they're good for, because long-life performance has come to be taken for granted. Yet, when you get right down to it, you'll find good reasons for this complete consumer confidence. And, from a "sparking" point of view, perhaps the most important is the almost universal use of special Hoskins alloys for the vital electrode wires.

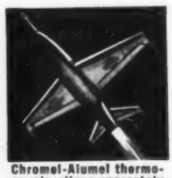
Producing the wire that sparks your car to power is a tough and tricky business. It requires special care in the selection of raw materials. Special melting and production techniques. Plus extremely close control over alloy composition and uniformity of quality throughout the entire manufacturing process.

Yet that's exactly the kind of alloy that Hoskins is qualified to produce best. For, among the other quality-controlled alloys developed and manufactured by Hoskins are: Alloy 717—for facing engine valves; Alloy 785—for brazing belts; Alloy 502—for countless heat resistant mechanical applications. Then, too, there are the Chromel-Alumel thermocouple alloys . . . guaranteed to register true temperature-EMF values within specified close limits. And, of course, Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.

Hot stuff for hot jobs! Hoskins Alloy 502 is ideally suited to many mechanical-structural applications.



Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.



Chromel-Alumel thermocouple alloys accurately measure exhaust temperatures of jet aircraft engines.

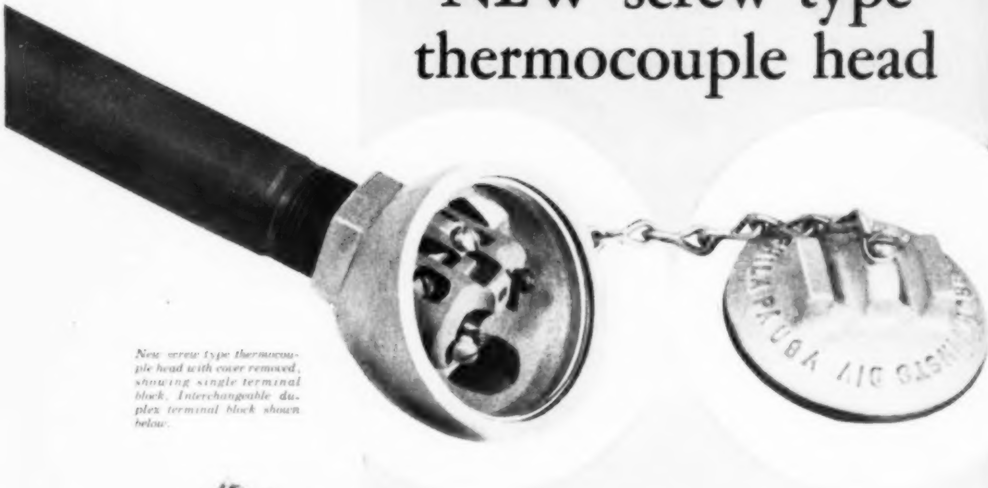
Chromel
NICKEL CHROMIUM WIRE

HOSKINS

MANUFACTURING COMPANY

4445 LAWTON AVENUE, DETROIT 8, MICHIGAN

NEW screw type thermocouple head



New screw type thermocouple head with cover removed, showing single terminal block. Interchangeable duplex terminal block shown below.

. . . now available through your

HSM

HONEYWELL SUPPLIES MAN

Here's a new Brown Screw Type Thermocouple Head that *cannot rust or freeze* . . . another plus value in the HSM Plan for convenient and economical purchasing of pyrometer supplies.

This unit effectively safeguards terminal connections from corrosive effects of high temperatures and extreme weather conditions.

Versatile: it accommodates single and duplex thermocouple, and resistance thermometer, terminal blocks . . . is interchangeable with other heads . . . and permits installation of twin thermocouples with a single head. Thus, your inventory of thermocouple heads is materially reduced.

Threads on the inside of the head . . . plus plating and enameling *after* machining . . . prevent freezing and rusting.

Call your local Honeywell Supplies Man for prices and delivery information, and for details on the HSM Plan for all your pyrometer supplies purchases . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls

● *Important Reference Data*

Write for a copy of New Pyrometer Supplies Buyers' Guide, No. 100-4

For Aluminum Die Casting

The NEW LESTER-PHOENIX HP·1·C

25″

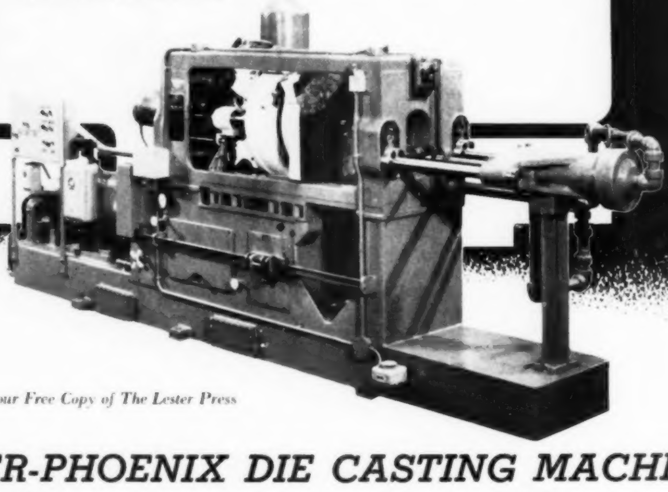
22″

DIE MAKER'S PRECISION

Like all Lester-Phoenix machines, the NEW HP-1-C has been designed to give you maximum production—day in, day out; year after year. The unsurpassed precision of the NEW, high speed, HP-1-C machine means higher quality die castings, longer die life, and flash-free die locking.

The shot cylinder and cold chamber are accurately supported in perfect alignment in either of two shot positions. There is no binding of the shot plunger and full pressure is delivered to the die. The solid frame is likewise finished to within .0005″ with die maker's precision. And, for maximum use, the new HP-1-C is convertible to the famous Self-aligning Zinc End.

These are the highlights of the new HP-1-C. The representative listed below in your area will be happy to explain all the features of this and other Lester-Phoenix Die Casting Machines.



Write for your Free Copy of The Lester Press

LESTER-PHOENIX DIE CASTING MACHINES

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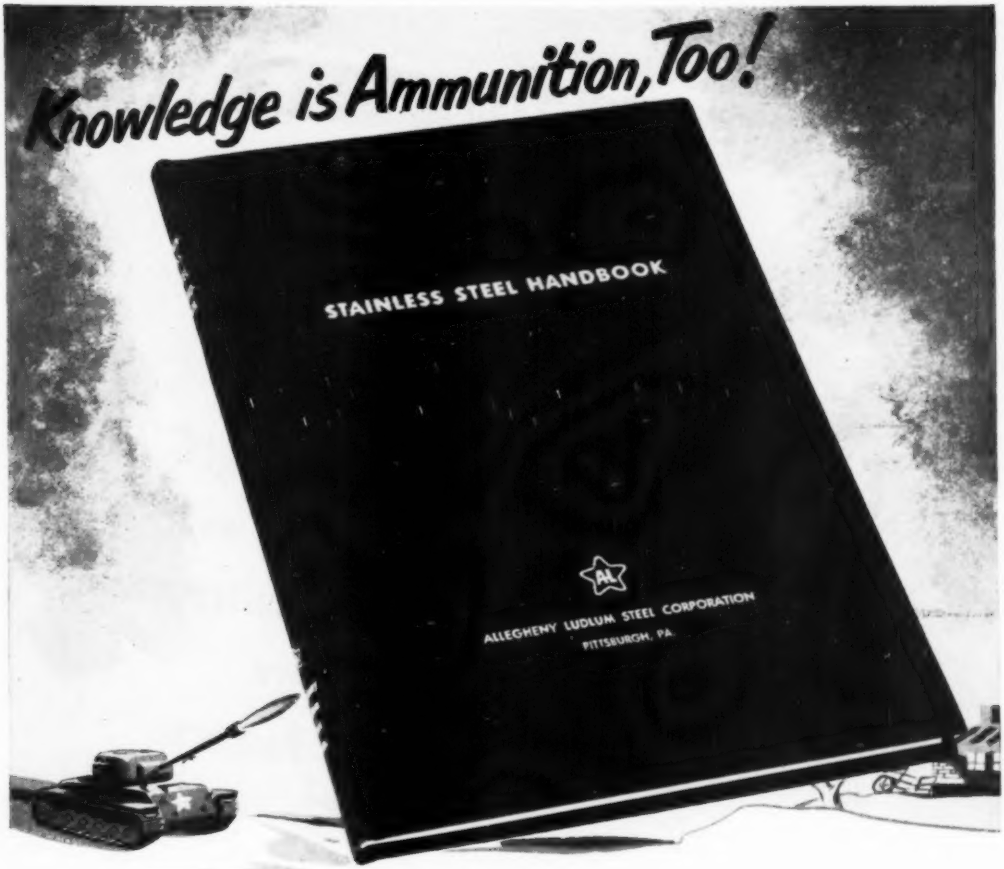


Here's 124 Pages of Valuable Data on STAINLESS STEEL

Stainless steel is a critical rearmament material. As the nation's mobilization program shifts into higher speed, supplies of this vital alloy are becoming increasingly restricted. If you're using stainless, be sure you make every pound go as far as possible.

Allegheny Ludlum's new 124-page, case-bound Stainless Steel Handbook is ready for distribution now. It will help you to select the right stainless steel and to use it right. Comprehensive listings of analysis, properties and characteristics of each type will guide you in specifying grades that will do your job most efficiently. Clear, concise fabrication data will help you speed production and cut waste.

Your copy of the Stainless Steel Handbook will be sent—*without charge*—upon request. Our only stipulation: please make your request upon your company letterhead. • Write Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.

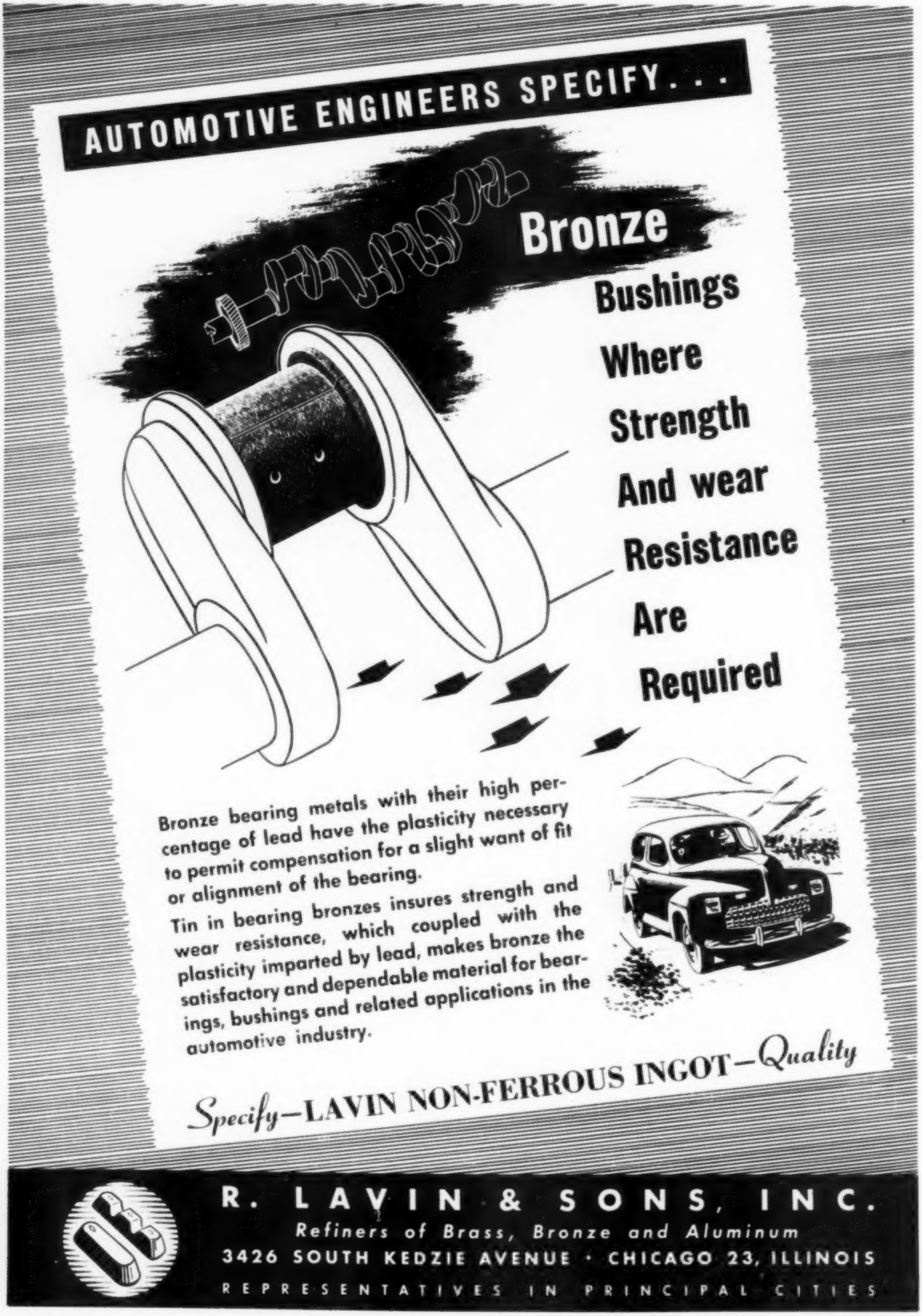
ADDRESS DEPT. MP-26

W&D 3947

Remember this also
America must have more Scrap to make more Steel!
Get in the Scrap Now!

You can make it **BETTER** with
Allegheny Metal

AL TIME-TESTED STAINLESS STEEL


AUTOMOTIVE ENGINEERS SPECIFY . . .
Bronze
Bushings
Where
Strength
And wear
Resistance
Are
Required
Bronze bearing metals with their high percentage of lead have the plasticity necessary to permit compensation for a slight want of fit or alignment of the bearing.
Tin in bearing bronzes insures strength and wear resistance, which coupled with the plasticity imparted by lead, makes bronze the satisfactory and dependable material for bearings, bushings and related applications in the automotive industry.
Specify—LAVIN NON-FERROUS INGOT—Quality
R. LAVIN & SONS, INC.
Refiners of Brass, Bronze and Aluminum
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REPRESENTATIVES IN PRINCIPAL CITIES

Manufacturers
LOOK FOR THIS SIGN
on the profit road . . .

Your profit for tomorrow will be decided by the work you produce today.

Keep every production line running with fewer breakdowns and less replacements by using ACCOLOY Heat and Corrosion Resistant castings.

The improved designs, finer grain size, the close control of pouring and the multiple testing of each finished piece, all contribute to the longer service life of these castings.

As a manufacturer using trays and fixtures, carburizing boxes, salt pots, retorts, muffles or roller rails — *make an investment now that will keep you posted on the profit side of the ledger.*

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

ALLOY ENGINEERING & CASTING COMPANY

ALLOY CASTING CO. (Div.)

CHAMPAIGN • ILLINOIS

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

The HOLE Story —by— *Superior*

Chapter 2

The Bubble That Beats Trouble to the Punch

In science, the arts and industry, fine small tubing serves many purposes, from the hypodermic injection of healing drugs to the control of hydraulic presses that produce airplane and tank components.

In every tubing job there is one prime requirement. The tube must not leak. Here at Superior we specialize in the production of high quality tubing in all practical metals . . . and we use many methods to insure the superiority of our product.

Precision gauges in the hands of experienced inspectors check for dimensional precision. High powered microscopes in our laboratories investigate grain structure. Chemical analysis maintains close control on metallurgy. And in our shops compressed air, under pressures to hundreds of pounds per square inch, is forced into tubing held under water to make sure that leaks are detected and eliminated.

The whole story of Superior is one of quality . . . in machines and methods, in men, and in the end result —fine small tubing to do tough jobs well.

This is a story with continuity, for our aim holds always to raise the standards by which we judge Superior tubing . . . and to continue to increase the rate at which we produce it to meet your demands.

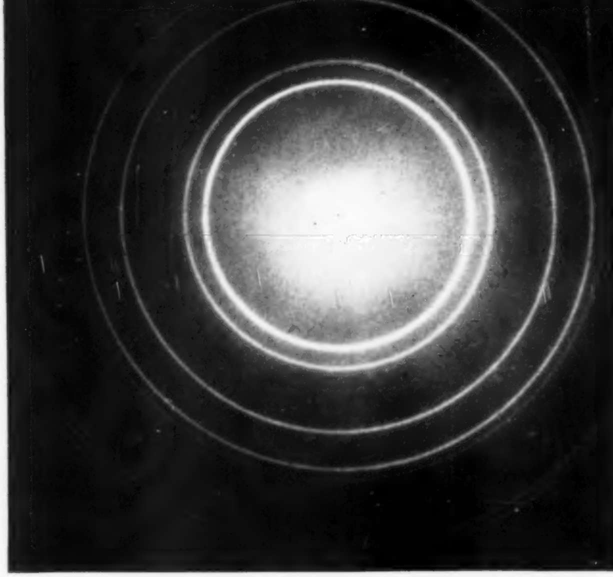
SUPERIOR TUBE COMPANY, 2008 Germantown Ave., Norristown, Pa.

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. UNderhill 0-1331.

Superior
THE BIG NAME IN SMALL TUBING

All analyses .010" to ⅝" O.D.
Certain analyses (.035" max. wall)
Up to 1⅜" O.D.

Aluminum SMOKE RINGS



Type EMD-2 complete with optical system, power supplies, vacuum system, and control panel. Features include: choice of optics to suit application; 5-control specimen positioning; ports for accessories; built-in charge neutralizer; antihalation beam stop; direct-viewing fluorescent screen; built-in 3-plate camera (4" x 5"); multiple specimen holders; high-speed electromechanical valving.

A diffraction pattern of metallic aluminum by

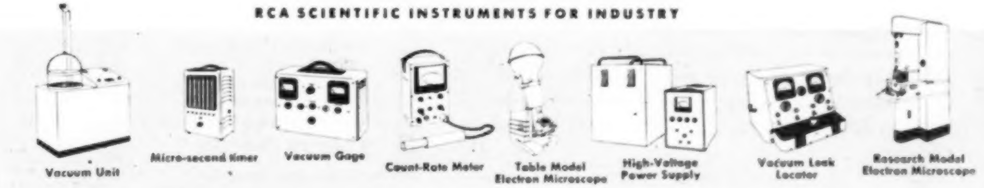
the RCA Electron Diffraction Unit, Type EMD-2!

THIS pattern reveals fundamental facts about the crystalline structure of an ultra-thin film of aluminum. The pattern was produced in an RCA Electron Diffraction Unit by bombarding the specimen with a beam of electrons—then capturing the diffraction pattern with a camera built right into the unit itself!

This instrument is unsurpassed for producing reflection and transmission diffraction patterns from micro-quantities of materials, surfaces, and monomolecular layers. Type EMD-2 makes it possible to distinguish between structures, or forms of materials, which have the same chemical composition but differ physically. In a matter of seconds it can produce clear, brilliant patterns of matter present in quantities too minute for X-ray diffraction. *It is the only means known for examining the atomic structure of true surfaces.*

Type EMD-2 is effective in work with metals, ceramics, plastics, organic films, biologicals, etc. Its usefulness for investigating corrosion, catalysts, lubricants, surface deposits, graphites, and pigments is well established. For complete data, write Dept. 72B, RCA Engineering Products, Camden, N. J.

RCA SCIENTIFIC INSTRUMENTS FOR INDUSTRY



RCA

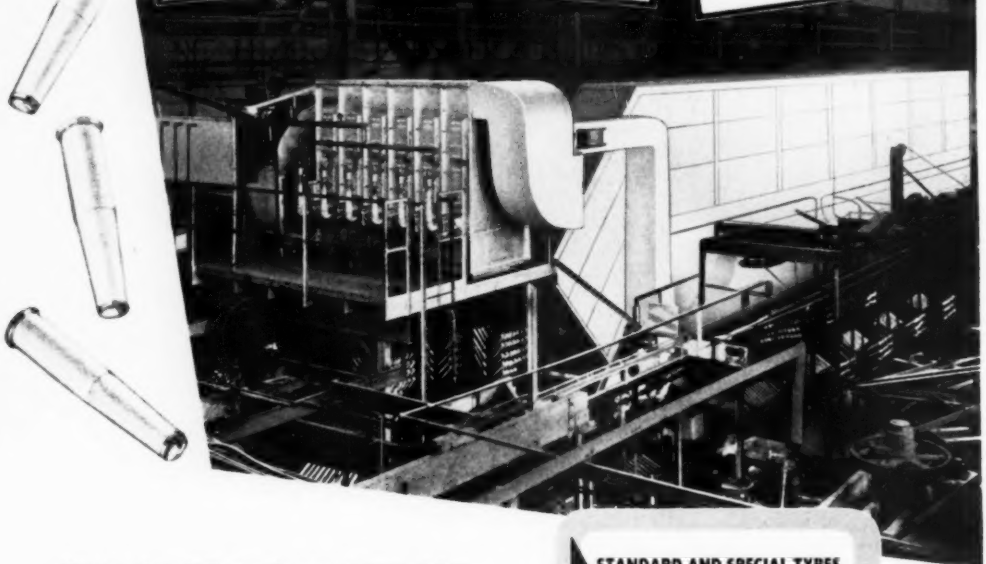
SCIENTIFIC INSTRUMENTS
RADIO CORPORATION of AMERICA
ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

...speed up defense production with

YOUNG BROTHERS

heat treating ovens



Heat treating shells is only one of many defense jobs that Young Brothers Ovens are handling with top efficiency. Today, Young Brothers Ovens, batch and conveyors types with accurately controlled temperatures up to 1000°, are speeding up production in hundreds of defense plants.

Through the services of Young Brothers engineers, you get the advantage of 55 years of experience in building ovens for your specific needs. These services—available without obligation—can help you speed up your production and cut costs. Write or call for more details.

STANDARD AND SPECIAL TYPES TO MEET PRODUCTION REQUIREMENTS AND PLANT CONDITIONS FOR SUCH PROCESSES AS:

- ANNEALING AND TEMPERING
- DRYING AND IMPREGNATING
- AGING PROCESSES
- NORMALIZING AND STRESS RELIEF
- HYDROGEN RELIEF AFTER PLATING
- PREHEATING PROCESSES
- TEMPER DRAWING

WRITE FOR BULLETIN 14T.

YOUNG BROTHERS COMPANY

1829 COLUMBUS ROAD CLEVELAND 13, OHIO

Established 1896

THE PICTURE. What does your imagination picture in the clouds? Do you see a poodle begging an old witch for a pork-chop, a lamb gamboling to the right, and what else? If you've "outgrown" your imagination, forget it.

Imagination!

Defense mobilizer Charles E. Wilson urges American industry to start planning *now* for new designs, materials, and processes for "the weapons of 1960 and 1970". He says, "We are preparing for a Buck Rogers era, the atomic-fission, supersonic, electronics age, when yesterday's brilliant ideas are already on the way to the scrap heap. . . . We are clamoring for the *ideas of tomorrow*."

Many have been *doing something* about that, General Alloys among the first! The need for expanding casting potential has long been obvious.

Imagination, the stuff of dreams, knows no boundary of space, or form, or budget. She may dance capriciously with elves in the moonlight, cut paper dolls from storm clouds, — even look down upon the stars.

But, make no mistake, she abounds in substance with eager power to lift you from your rut! She is the opportunity that knocks from *within*. If you have the *spirit* to transcend mediocrity, you will hear and follow. She is sprightly, incandescent, elusive, at times fickle. She will pause to aid him who hopes and tries *and tries* to untie the *smallest* knot or solve the *toughest* riddle. She will project your thought over any route you plan to travel and point out, *through your pencil*, all of the obstacles which lay-in-wait, and the short-cuts to your goal.

Imagination has Patience; she will linger while you break with Precedent, smile while you dally with Habit, then guide you to Understanding. But you, too, must have Patience, and the wisdom not to form conclusions in ignorance, or base your belief on the "thinking" of others.

For her own amusement she has given names to a thousand Gods, spun the priestly potter to beget the clods and stones to build a million temples (complete with turnstiles). She has paved the streets of Heaven with Gold and of Hollywood with mink and long ranges of firm, pink mountains. She had a hand in Esquire's Calendar, and should shortly produce needed improvements on "Dynaflow and Hydramatic". For the first time in a generation she is striving to raise the sights at Pullman-Standard and bring a bold new vista of modernized rail transport into form.

Imagination, in the automotive field, wears Seven League Boots. Nowhere has she fired the minds of men as in motors and aviation where the only certainty is *Change* and all motion adds to Progress! When we stuck our necks out to form the first enterprise wholly devoted to the Engineering and Casting of Heat and Corrosion Resistant Alloys, we cast our lot with the men of automotives. It has been a privilege to serve them, and to share their restless dissatisfaction with things in being as they plan and build with imaginative vision and inspired vigor.

Automotive "Precedents" are born "notched" to facilitate breaking. In this respect they differ from the "Cast-iron" Precedents of the foundry industry to which background the casting of complex alloys was fused by happenstance and/or necessity. We grew up with our feet mired in the technical stagnation of the foundry. Our minds expanded with the exploration and conquest of uncharted metallurgical fields in the metallurgy of complex alloys. Meanwhile we shared the Imagination and the "Loyalty to the Vision of Work well done" of the automotive, and later the Process, Industries.

From such breadth of activity and conflict of technological concept, over a quarter century, we developed an approach to the evaluation of our own ignorance. Surely, in our diversity of alloys, in the unprecedented degree of metallurgy, of engineering design and application we applied, nation-wide, to thousands of "Severe Service" installations. We followed no published art, no path trod by foundrymen.

When we projected a comprehensive program of Research and Development for (a) more accurate control of as-cast structures, (b) improved dimensional control of castings, and (c) the elimination of sands, and related defects, from castings, we sought to eliminate all questionable data. This meant discounting or completely eliminating all data on conventional foundry practice in steel and alloys. So we started from "Scratch".

Enter Imagination. Let us imagine that there were no foundries, that (a) we were given the problem of melting and casting metals to highest "practical" specifications, economically, in commercial quantities, (b) that we had access to all existent and historical art and technology on casting processes, (c) that we could enlist all known arts and technology in any desired combination, (d) that we were free to project and evolve new techniques and build the tools to implement them.

For two and a half years we have been living that "Dream", through Navy sponsorship of a Casting Research and Development Project. Imagination, implemented by stout hearts, hard work and sharp tools, has led us across frontiers.

Working "from the rim toward the hub", through a complexity of dynamic variables, we have precipitated the basic concepts, established the fundamental controls, by which the casting of metals can be immeasurably advanced. The conclusions appear, as do all reductions to logic, *simple and obvious*. In thus confirming our contention that "Good practice is sound theory reduced to function", we have found satisfaction. Imagination has *delivered* the goods. We will keep her on the payroll, *forever insubordinate!*

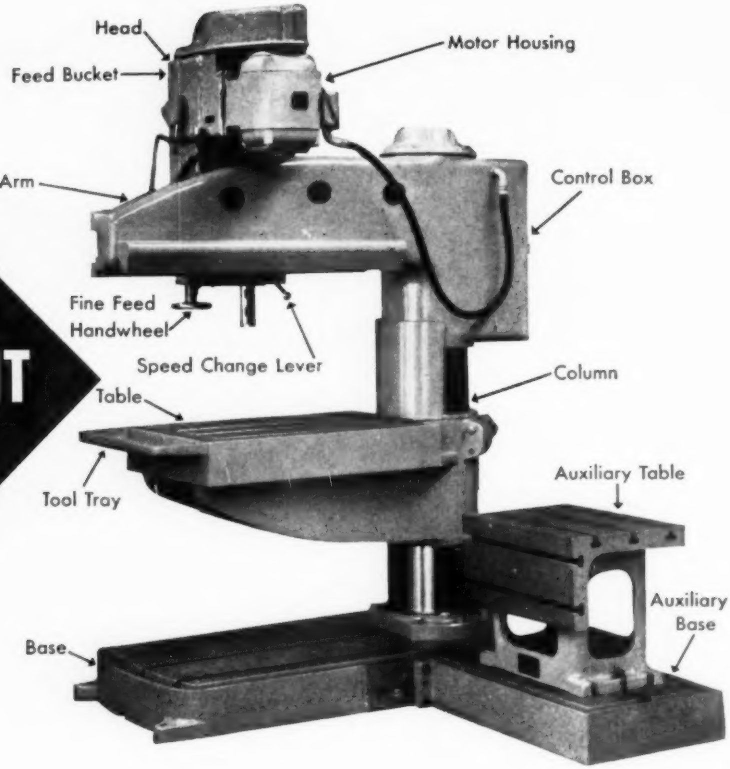
H. H. HARRIS

An "aditorial" reprinted from December, 1949, Metal Progress, by the President of General Alloys Company, "Oldest and Largest Exclusive Manufacturers of Heat and Corrosion Resistant Castings" — Boston, Mass.

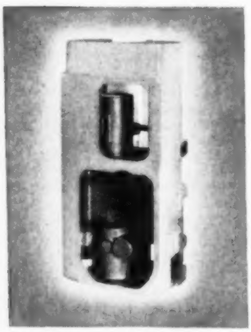
THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

THERE'S ONLY

ONE RIGHT WAY...



specify GRAY IRON castings!



This head casting is typical of the intricately shaped, rigid members that give the perfect life-long alignment essential in machine tool operation.

20 PARTS OF THIS RADIAL DRILL ARE GRAY IRON CASTINGS (13 are visible in this photo) because by using gray iron this manufacturer has achieved rigid, durable construction obtainable with no other metal.

WHETHER A PART OR ASSEMBLY is plain or intricate—if it calls for vibration absorption, strength and wear resistance at low cost—you can't afford to overlook the advantages of gray iron castings. Gray iron offers an unmatched combination of characteristics to meet today's design problems.

GRAY IRON CHARACTERISTICS INCLUDE: Castability • Rigidity • Low Notch Sensitivity • Wear Resistance • Heat Resistance • Corrosion Resistance • Durability • Vibration Absorption • Machinability • Wide Strength Range.

Make it better with Gray Iron

SCRAP IS NEEDED FOR DEFENSE—KEEP IT MOVING!

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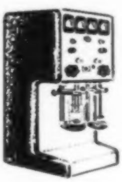

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Accurate tensile, creep and stress-rupture tests of alloys at high temperatures require a tubular furnace in which uniform temperature can be maintained throughout long or short tests. Marshall furnaces have proven unsurpassed in this service!

Marshall Furnaces are designed with heating element coils correctly spaced on the core — securely anchored. The "zone-by-zone" control of temperature can be adjusted from outside the furnace. Marshall furnaces will aid you to get *accurate* tests data. Try them!

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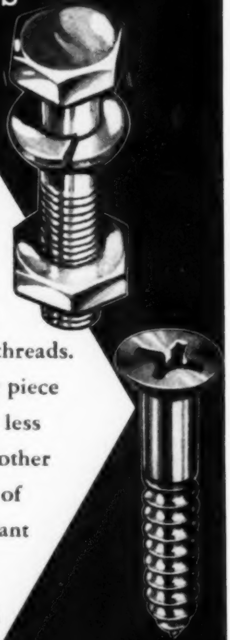

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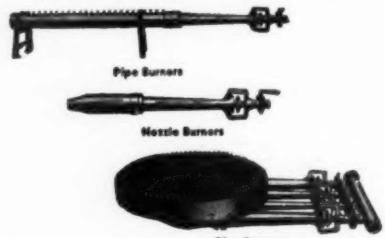

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SOLDERING
AND BRAZING GUN

This new MOGUL unit is built to deposit lead and tin base solders, silver solder and brazing wires in a liquid or semi-liquid form to any constant moving part.

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Saves Time • Saves Solder

Recent installation of a Mogul Gun afforded a reduction of 75% in labor costs plus appreciable solder savings. Perhaps Mogul can do the same for you. Write today for full information.

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Every pound of dormant scrap <u>you</u> can furnish will help to keep the steel mills and foundries producing

Steel mill furnaces are gobbling up scrap faster than it's being delivered. To maintain planned schedules of steel production for both military and civilian purposes, the mills must have *more* iron and steel scrap.

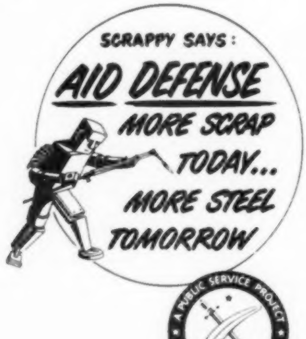
Get in the Scrap—Yourself!

Whatever your business, you undoubtedly have scrap. If there's dust on it or rust on it—it may be scrap. If it's scrap—it's *needed*.

Turn it over to your local scrap dealer and help lick this critical scrap shortage.

What you can do to help

1. Appoint one top official in your plant to take full responsibility for surveying the plant and getting out the scrap.
2. Consult with your local Scrap Mobilization Committee about its program to help out in the scrap crisis. The nearest office of the National Production Authority, Department of Commerce, can tell you who your local Scrap Mobilization chairman is.
3. Call in your local scrap dealer to help you work out a practical scrapping program. Non-ferrous scrap needed, too!
4. Write for free booklet, "Top Management: Your Program for Emergency Scrap Recovery", addressing Advertising Council, 25 W. 45th St., N. Y. 19.



FACTS YOU SHOULD KNOW ABOUT STEEL PRODUCTION

Steel production	1950	97,800,000 net tons
Estimated capacity	1952	119,500,000 net tons
Purchased scrap used*	1950	29,500,000 gross tons
Estimated purchased scrap requirement*	1952	36,200,000 gross tons

*All consumers

This advertisement is a contribution, in the national interest, by

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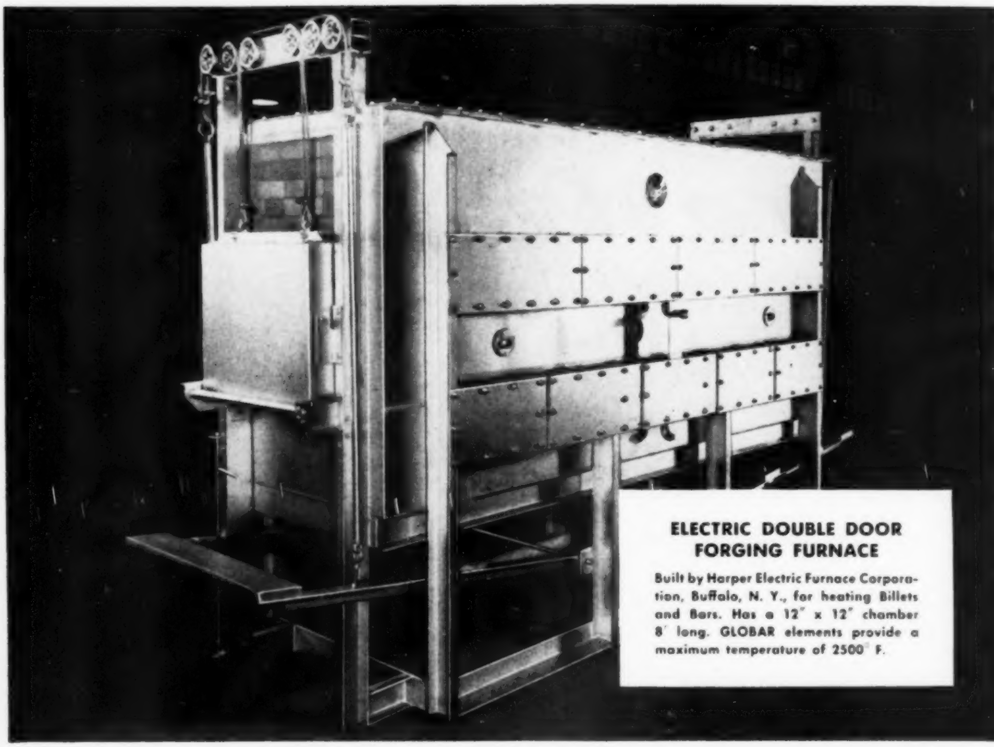
METAL PROGRESS



HARPER ELECTRIC FURNACES

can help you produce precision forgings

GLOBAR Heating Elements are a key factor

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This means ... in heating steels and alloys to forging temperatures ... that you can prevent decarburization by means of a protective atmosphere while establishing definite reproductive quality control. The result ... better, more uniform forgings.

To obtain these advantages, the Harper design incorporates the unique characteristics of GLOBAR silicon carbide heating elements. These non-metallic elements offer many other benefits as well. We'd like to tell you more about them ... what they can do for you in a variety of heating applications. Write us at Dept. MP 87-104, The Carborundum Company, GLOBAR Division, Niagara Falls, N. Y.

GLOBAR Heating Elements

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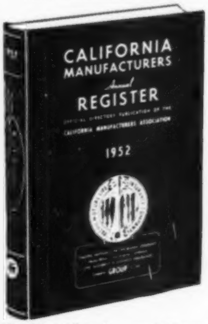

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960 TOOL STEELS

analyzed and compared

THE SELECTION AND HARDENING OF TOOL STEELS

By L. H. Seabright

Research Engineer, Vulcan Stamping and Mfg. Co.

263 pages, 70 illustrations, \$5.50

This book offers metallurgists, tool steel users, tool designers, and others, a quick, easy method for singling out the tool steel which fits particular needs most accurately. It emphasizes the relationship between steels as they are actually used in industry. It classifies standard tool steels into 12 main groups and 40 sub-groups, in which the group members are interrelated in terms of their properties and average hardening and tempering speeds. For each sub-group, complete data on heat treating and tempering is given. The book discusses the effect of minor variations in composition on the properties of the tool steel concerned, and such heat treating developments as martempering and salt-bath quenching.

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- chrome-vanadium steel
- graphitic-silicon steel
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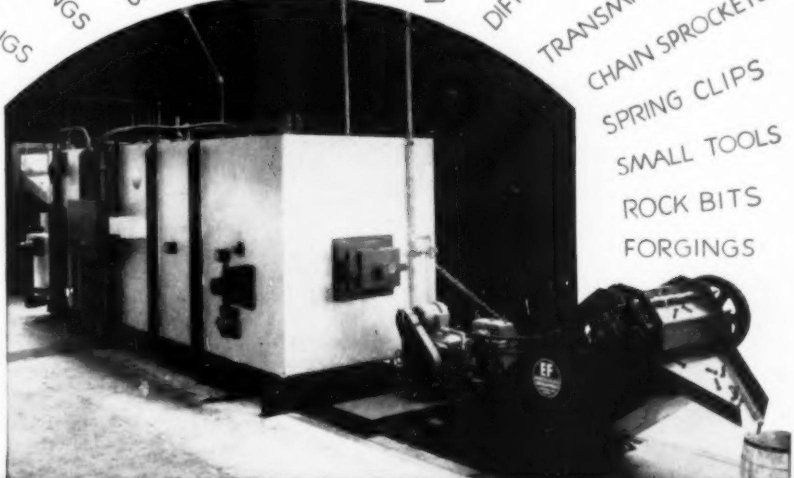

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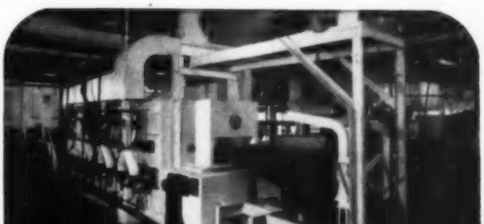

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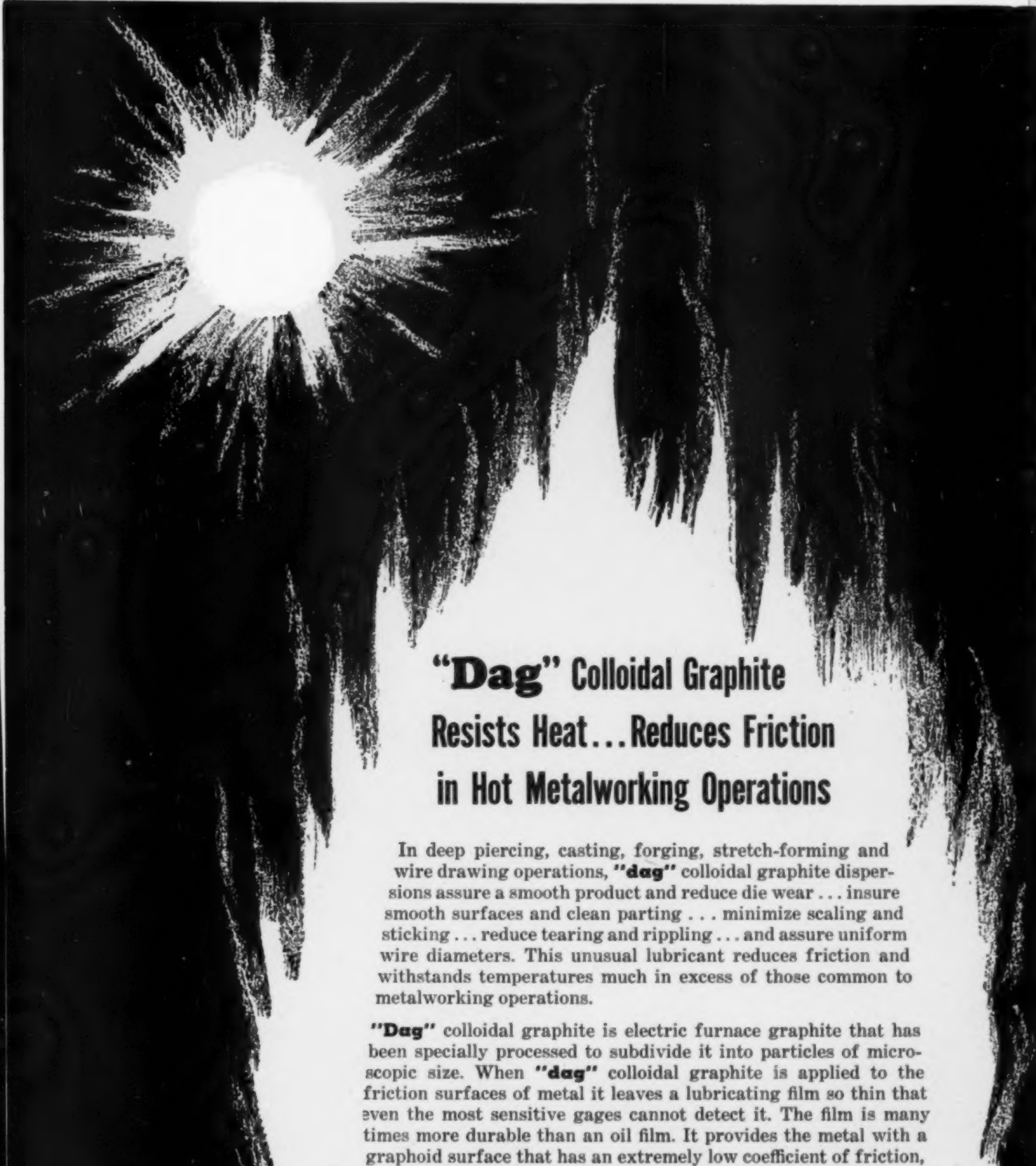
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